



BOYS' AND
GIRLS'
BOOKSHELF

THE BOOK HOUSE



A BOOK is just a House of Thought,
Where many Things and People live.
Beyond its doors Great Things are taught,
And all its Dwellers give and give.
So walk right through the open door
With kindly Heart and brain awake.
You'll find in there a Wonder Store
Of Good Things, all for you to take.

The Dwellers in *your* Book House know
All sorts of tales to tell to you,
And each will try his best to show
The way those tales of Wonder grew.
For this our Book House Friends expect
A trifling payment in return;
Just thoughtful Kindness and Respect,—
That's all they ask for all we learn.

John Martin

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This BOOK belongs to

Miss Harriet Vinton

THE BOOK TREE

A BOOK TREE is a Knowledge Tree,
As almost anyone can see.

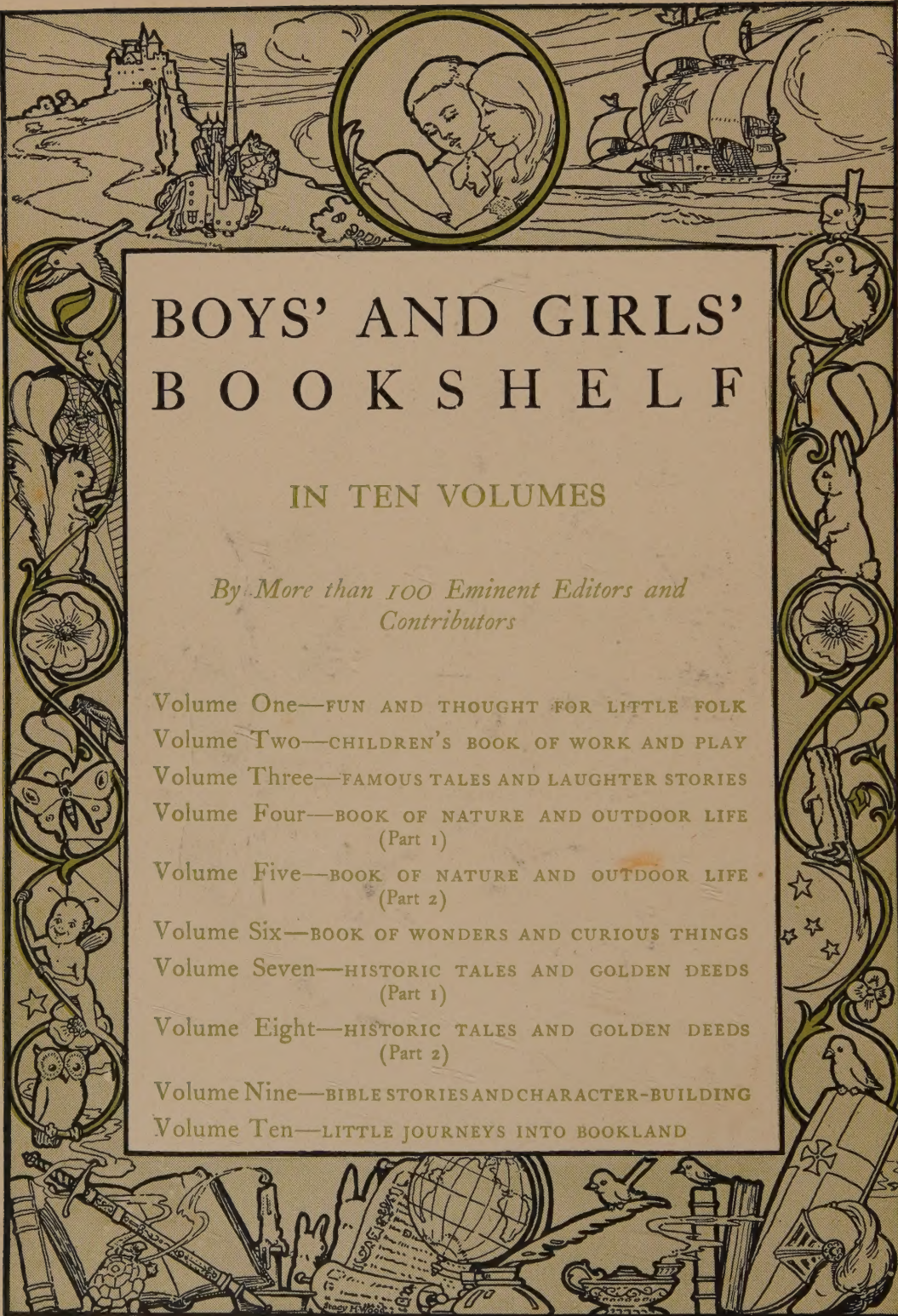
Long, long ago its seed was sown;
For years and years the Tree has grown.
Ten thousand thousand Hearts & Heads
Have cared for it, so now it spreads
Its Roots and Branches far and wide,
And casts its shade on every side.

This Tree bears Fruit of different kinds
For many Hearts and many Minds.
So all you Children have to do
Is just to take what's best for you.
But no one ever soils or breaks
The Golden Fruit he needs and takes,
And no one ever bends or tears
The Books this Tree of Knowledge bears.

John-martin







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*By More than 100 Eminent Editors and
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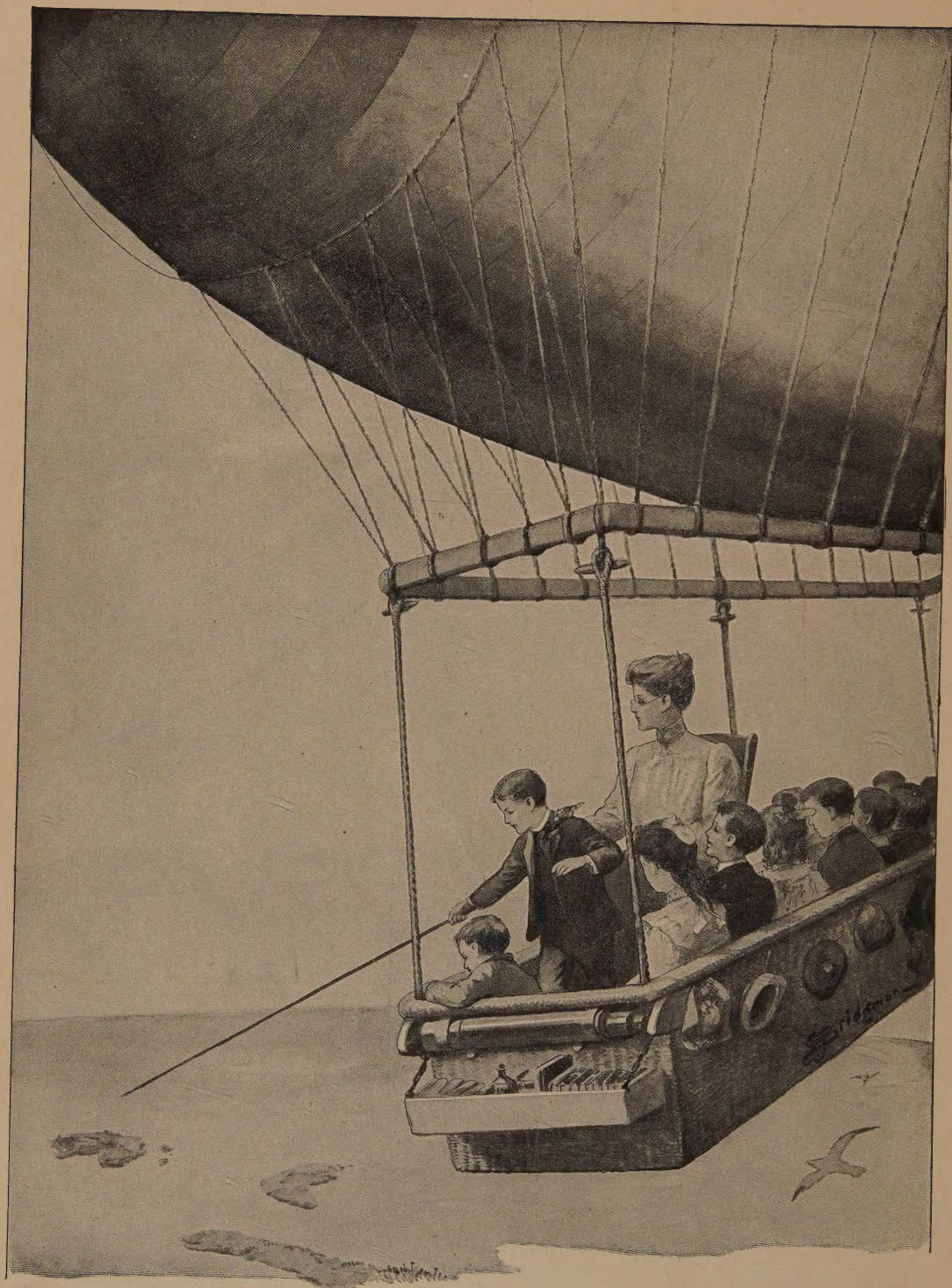
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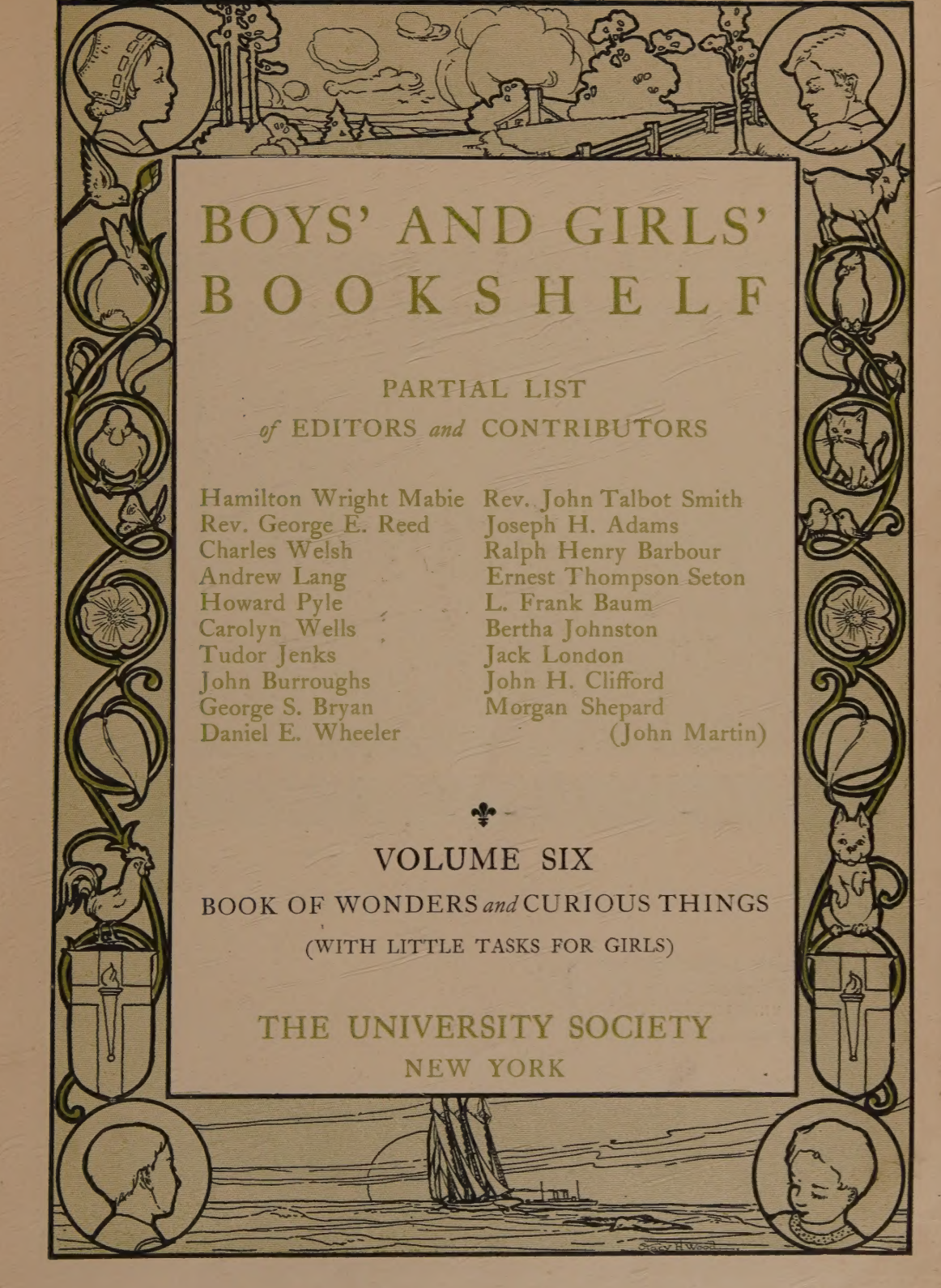
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IN 1950. THE CLASS IN HISTORY.

TEACHER: "NOW, JOHNNY, TAKE THE POINTER AND SHOW THE CLASS JUST THE SPOT
WHERE COLUMBUS LANDED."



BOYS' AND GIRLS' BOOKSHELF

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VOLUME SIX

BOOK OF WONDERS *and* CURIOUS THINGS

(WITH LITTLE TASKS FOR GIRLS)

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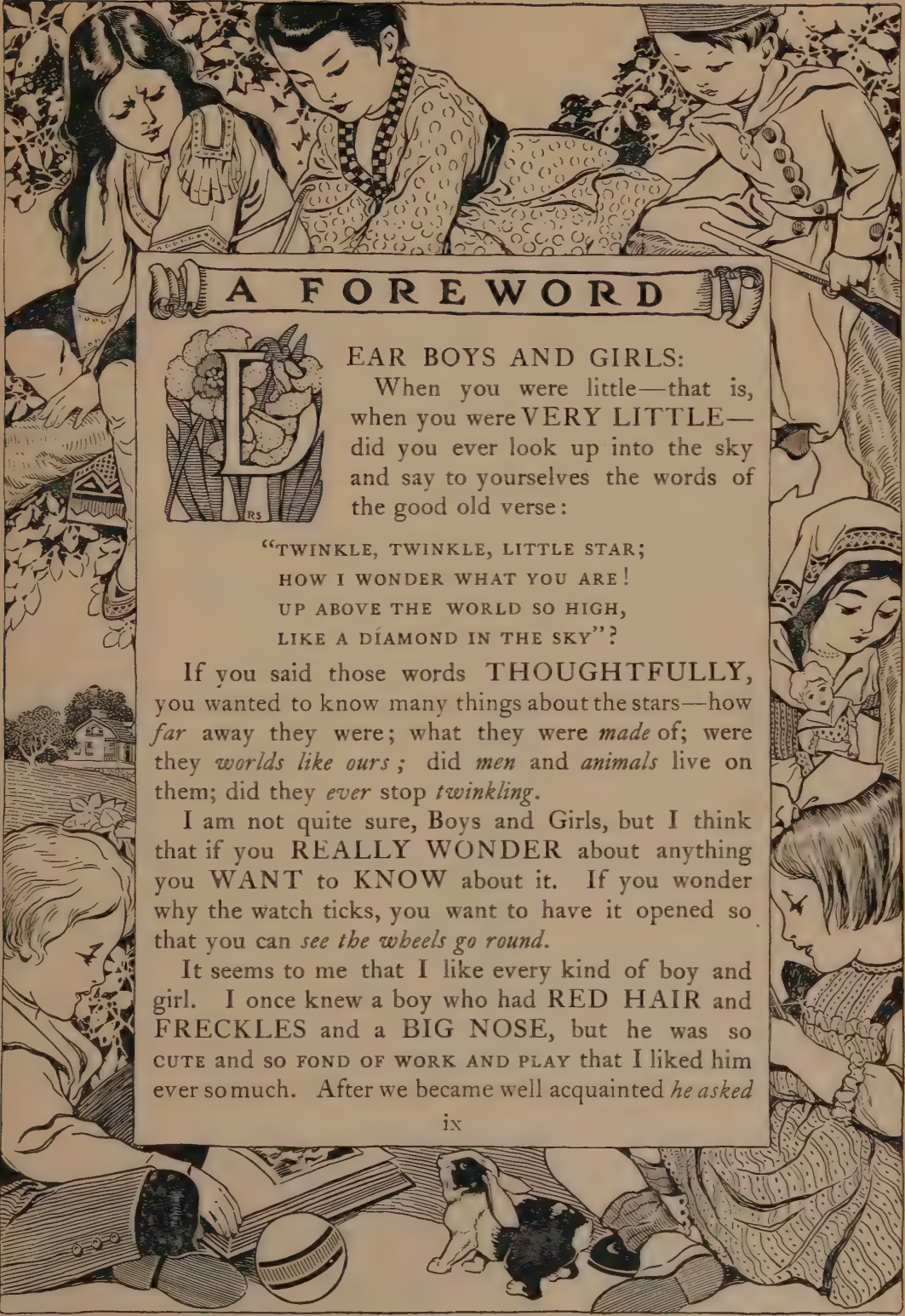
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A detailed black and white illustration of children in traditional Japanese clothing. At the top, a girl and a boy are looking down at something. To the right, another boy is writing with a brush. On the left, a girl is looking down. At the bottom, a boy is reading a book, and a small dog is sitting next to him. The background features a house and trees.

A FOREWORD



DEAR BOYS AND GIRLS:

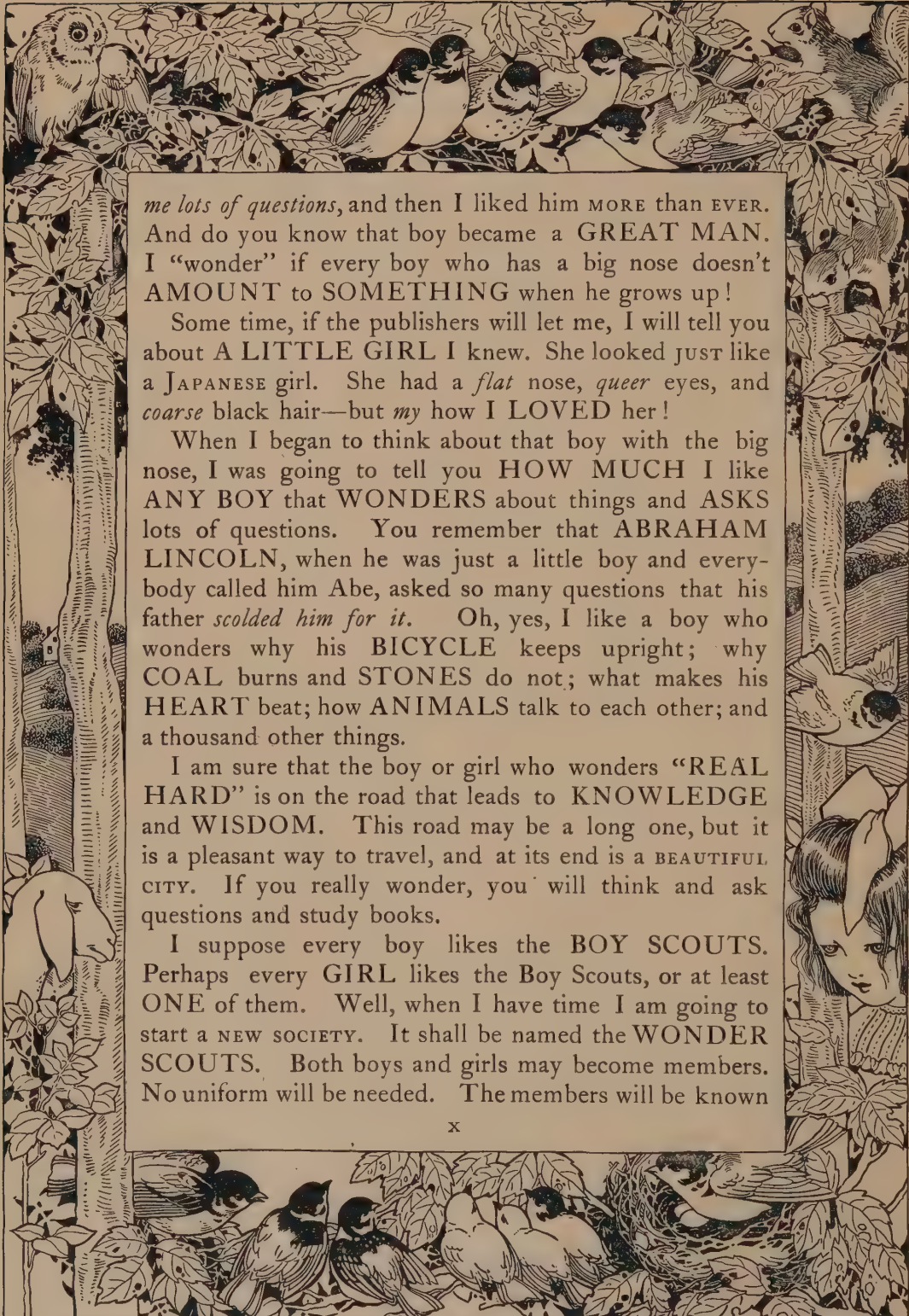
When you were little—that is, when you were **VERY LITTLE**—did you ever look up into the sky and say to yourselves the words of the good old verse:

“TWINKLE, TWINKLE, LITTLE STAR;
HOW I WONDER WHAT YOU ARE!
UP ABOVE THE WORLD SO HIGH,
LIKE A **DÍAMOND** IN THE SKY”?

If you said those words **THOUGHTFULLY**, you wanted to know many things about the stars—how *far* away they were; what they were *made of*; were they *worlds like ours*; did *men and animals* live on them; did they *ever stop twinkling*.

I am not quite sure, Boys and Girls, but I think that if you **REALLY WONDER** about anything you **WANT** to **KNOW** about it. If you wonder why the watch ticks, you want to have it opened so that you can *see the wheels go round*.

It seems to me that I like every kind of boy and girl. I once knew a boy who had **RED HAIR** and **FRECKLES** and a **BIG NOSE**, but he was so **CUTE** and so **FOND OF WORK AND PLAY** that I liked him ever so much. After we became well acquainted *he asked*



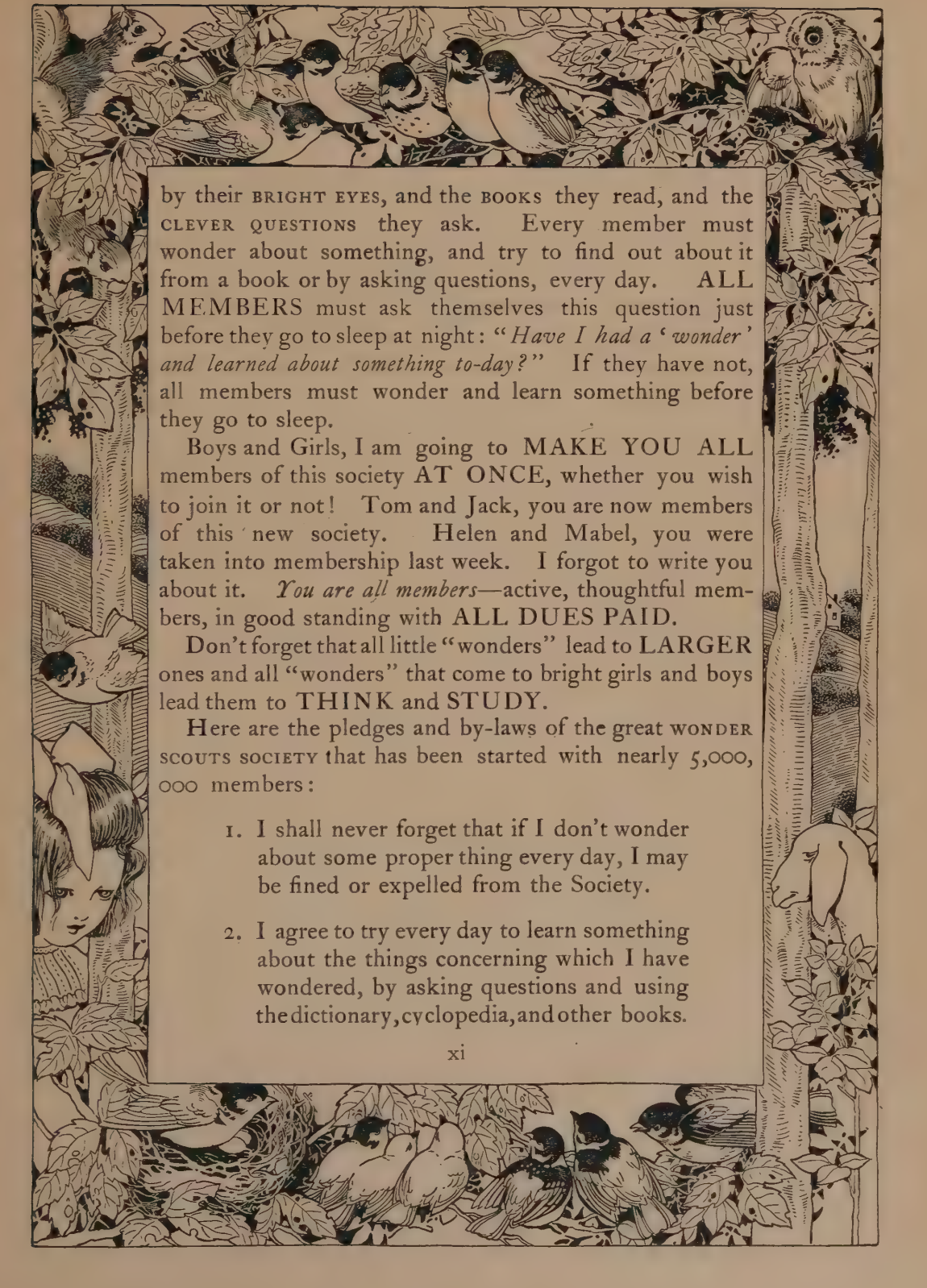
me lots of questions, and then I liked him MORE than EVER. And do you know that boy became a GREAT MAN. I "wonder" if every boy who has a big nose doesn't AMOUNT to SOMETHING when he grows up!

Some time, if the publishers will let me, I will tell you about A LITTLE GIRL I knew. She looked just like a JAPANESE girl. She had a *flat* nose, *queer* eyes, and *coarse* black hair—but *my* how I LOVED her!

When I began to think about that boy with the big nose, I was going to tell you HOW MUCH I like ANY BOY that WONDERS about things and ASKS lots of questions. You remember that ABRAHAM LINCOLN, when he was just a little boy and everybody called him Abe, asked so many questions that his father *scolded him for it*. Oh, yes, I like a boy who wonders why his BICYCLE keeps upright; why COAL burns and STONES do not; what makes his HEART beat; how ANIMALS talk to each other; and a thousand other things.

I am sure that the boy or girl who wonders "REAL HARD" is on the road that leads to KNOWLEDGE and WISDOM. This road may be a long one, but it is a pleasant way to travel, and at its end is a BEAUTIFUL CITY. If you really wonder, you will think and ask questions and study books.

I suppose every boy likes the BOY SCOUTS. Perhaps every GIRL likes the Boy Scouts, or at least ONE of them. Well, when I have time I am going to start a NEW SOCIETY. It shall be named the WONDER SCOUTS. Both boys and girls may become members. No uniform will be needed. The members will be known



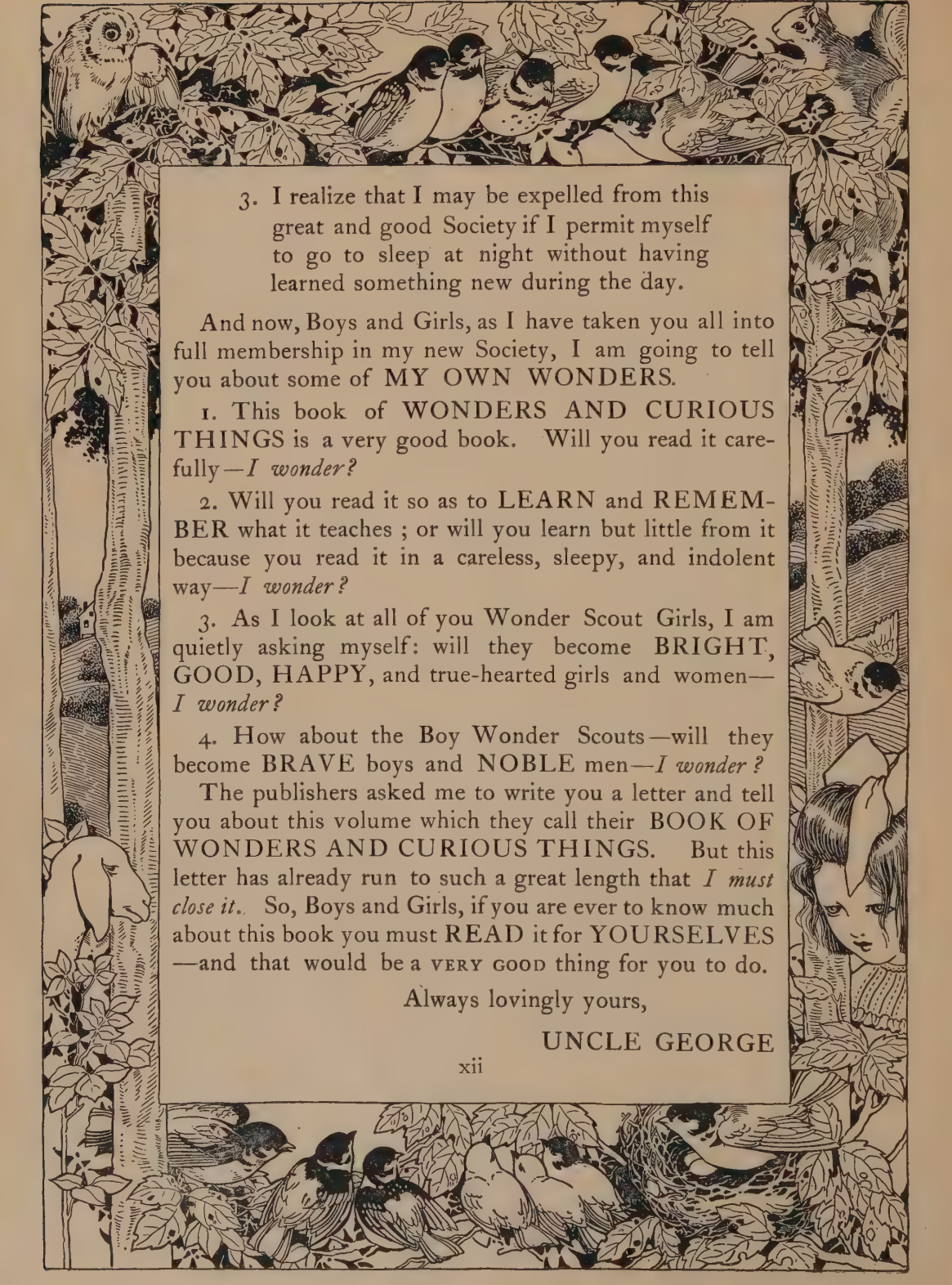
by their BRIGHT EYES, and the BOOKS they read, and the CLEVER QUESTIONS they ask. Every member must wonder about something, and try to find out about it from a book or by asking questions, every day. ALL MEMBERS must ask themselves this question just before they go to sleep at night: "*Have I had a 'wonder' and learned about something to-day?*" If they have not, all members must wonder and learn something before they go to sleep.

Boys and Girls, I am going to MAKE YOU ALL members of this society AT ONCE, whether you wish to join it or not! Tom and Jack, you are now members of this new society. Helen and Mabel, you were taken into membership last week. I forgot to write you about it. *You are all members*—active, thoughtful members, in good standing with ALL DUES PAID.

Don't forget that all little "wonders" lead to LARGER ones and all "wonders" that come to bright girls and boys lead them to THINK and STUDY.

Here are the pledges and by-laws of the great WONDER SCOUTS SOCIETY that has been started with nearly 5,000, 000 members:

1. I shall never forget that if I don't wonder about some proper thing every day, I may be fined or expelled from the Society.
2. I agree to try every day to learn something about the things concerning which I have wondered, by asking questions and using the dictionary, cyclopedia, and other books.

- 
3. I realize that I may be expelled from this great and good Society if I permit myself to go to sleep at night without having learned something new during the day.

And now, Boys and Girls, as I have taken you all into full membership in my new Society, I am going to tell you about some of MY OWN WONDERS.

1. This book of WONDERS AND CURIOUS THINGS is a very good book. Will you read it carefully—*I wonder?*

2. Will you read it so as to LEARN and REMEMBER what it teaches ; or will you learn but little from it because you read it in a careless, sleepy, and indolent way—*I wonder?*

3. As I look at all of you Wonder Scout Girls, I am quietly asking myself: will they become BRIGHT, GOOD, HAPPY, and true-hearted girls and women—*I wonder?*

4. How about the Boy Wonder Scouts—will they become BRAVE boys and NOBLE men—*I wonder?*

The publishers asked me to write you a letter and tell you about this volume which they call their BOOK OF WONDERS AND CURIOUS THINGS. But this letter has already run to such a great length that *I must close it.* So, Boys and Girls, if you are ever to know much about this book you must READ it for YOURSELVES—and that would be a VERY GOOD thing for you to do.

Always lovingly yours,

UNCLE GEORGE

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GREAT MECHANICAL MARVELS

PART I

THE BUILDING OF A GIANT LINER

BY W. G. FITZGERALD

ALTHOUGH Ireland is supposed to be a very poor country, it is a curious fact that in her city of Belfast is built a larger percentage of magnificent ocean liners than anywhere else in the world. For there is one "yard" in that city turning out with monotonous regularity great steamships like the *Adriatic* of the White Star line. The gross tonnage of this enormous ship is 25,000, and she transports nearly 4000 souls across the broad Atlantic in less than a week.

Imagine what a hive of industry and machinery must be the place where such colossal ships are born. Think of 14,000 men, assisted by a whole world of thunderous engines, extending over eighty acres, and all at work upon gaunt skeletons which in a few brief months will be floating palaces of the sea!

In one year eight of these giants were launched, and they developed altogether the power of more than 100,500 horses. Most of them have nine decks, and carry about 3000 passengers and a crew of 500 or 600. Glance for a moment at the *Adriatic*, which, when built, was the largest vessel in the world.

Her length—about 750 feet—exceeds that of two towering skyscrapers placed one on top of the other; and her funnels, being 24 feet in diameter, would easily admit a couple of full-sized trolley-cars driven abreast throughout their whole length of 155 feet! Passengers taking their morning stroll on deck will understand that a circuit of the ship three and a half times means covering almost exactly a mile.

As the vessel lies on the ways, one obtains an admirable idea of her vastness. It is like looking up at one of the pyramids; only, instead of rising from a desert, the towering hull commands one of the busiest industrial hives of men. Stand on the forecastle in the very eyes of the leviathan, and the ground is nearly 100 feet below.

A confused hum floats up from the joiners' and blacksmiths' shops, for all are busy upon the giant carcass which, even in this bare state, weighs over 16,000 tons—even without engines, boilers, and palatial accommodation for passengers.

A full company of passengers, the water in her boilers, her stores, and her 7000 tons of coal, raise the ship's weight, without cargo, to 45,000 tons. The lowest deck of all is known as the "lower orlop"; then, rising tier by tier, we have the orlop, lower, main, upper, shelter, promenade, upper promenade, and boat—nine decks in all. A ship like this appears almost unsinkable, being divided into no less than 175 separate watertight compartments.

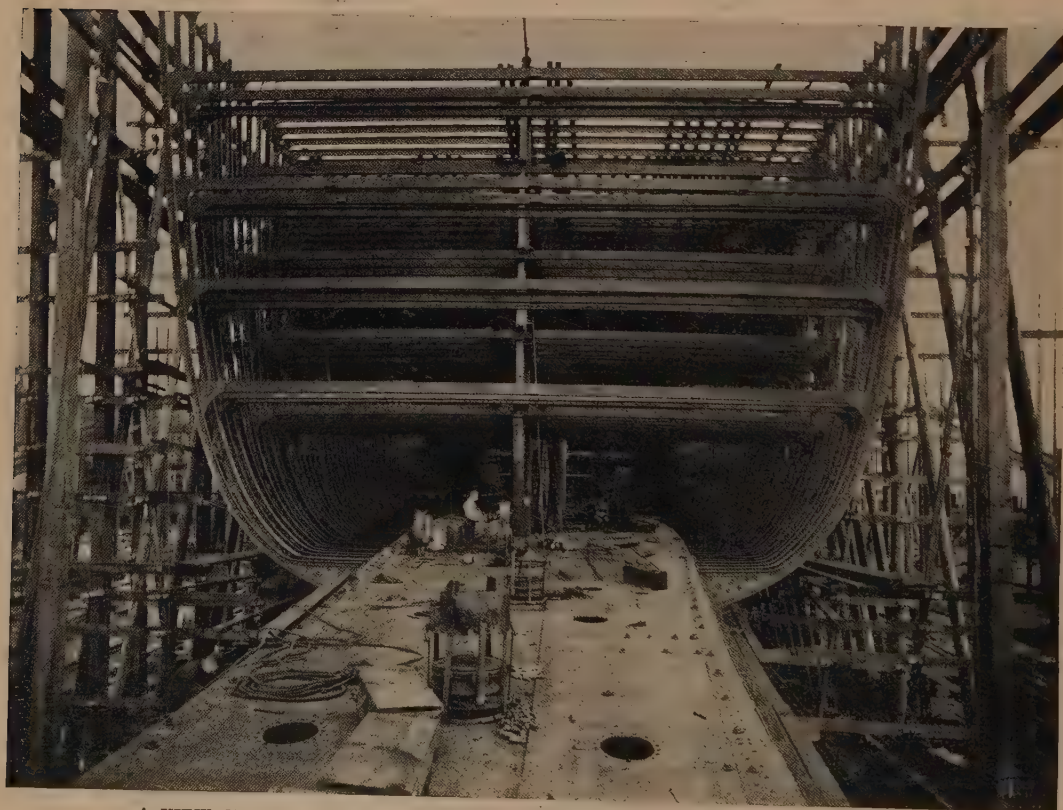
Her vast ribs are covered with 26,000 steel plates, the largest 40 feet long, and weighing about five tons. To fasten these to the mighty structural framework took 4,500,000 rivets, and some of these weighed three pounds. The rudder alone weighs 65 tons, or, including the castings for the steam, stern-post, and shaft-bracket, 280 tons. Three anchors of ten tons each are carried to control the giant, and each is provided with 1800 feet of cable, made up of 22-inch links, the iron in which is nearly four inches in diameter. Think of a chain of which every link weighs a hundredweight and a half!

There are even electric elevators for both passengers and mails. As to the electric light, there are over 5000 lamps fed by 200 miles of cable. One novel feature is a kind of central inquiry bureau which may be rung up by any one of the thousands of passengers upon any matter on which information is desired. Is it any wonder that such a ship would require a strength of 70,000 horses to drive her across the ocean?

And in the place where such ships are built there is also a kind of marine hospital where sur-



BOW VIEW OF THE "ADRIATIC." COATING HER SIDES WITH 26,000 STEEL PLATES.

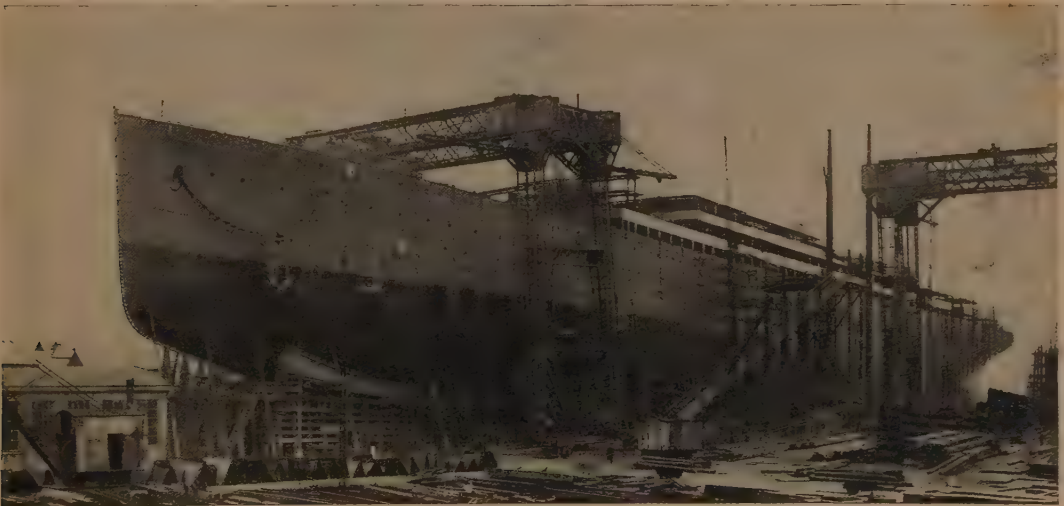


A VIEW OF THE SHIP PARTLY FRAMED, AND SHOWING THE TANK TOP PLATING.

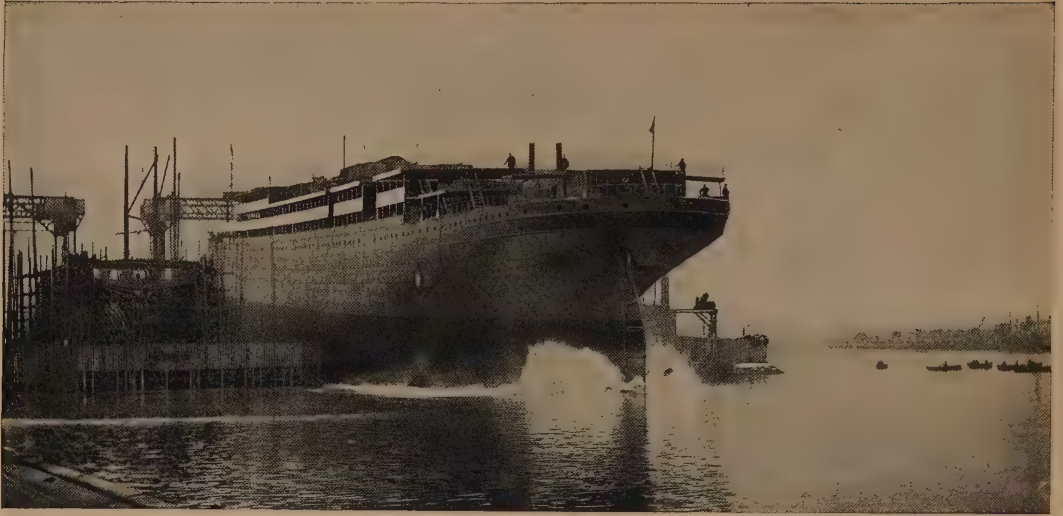


THIS IS NOT A RAILROAD BUT MERELY THE PROMENADE DECK OF THE "ADRIATIC" IN COURSE OF CONSTRUCTION AT BELFAST.

gical operations on a vast scale are conducted. and her bottom had to be entirely reconstructed. The great Indian liner *China*, for example, was a Another case was the *Paris*, renamed the *Philadelphia*. She had run onto the dreaded Manacles patient. She sank in the Red Sea near Perim,



THE COMPLETED HULL ON THE STOCKS READY FOR LAUNCHING.



THE LAUNCHING OF THE STEAMSHIP "ADRIATIC;" LEAVING THE WAYS.

Rocks off the coast of Cornwall, England, and required an entirely new stern, as well as new engines and boilers.

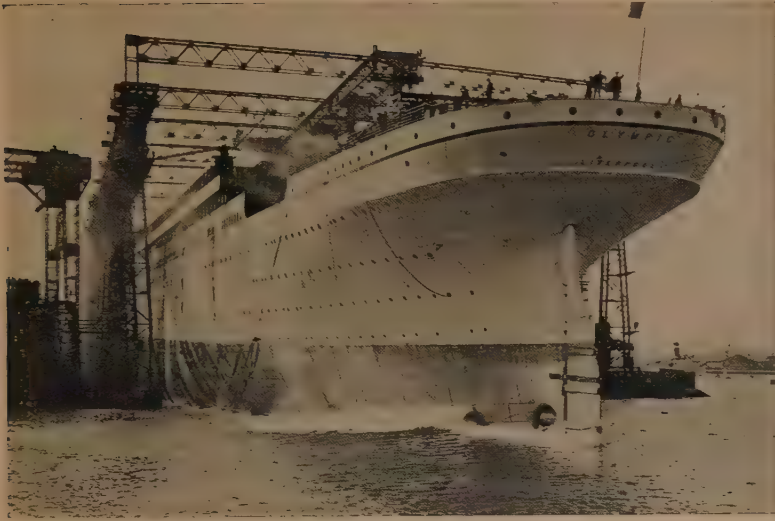
Again, the South African liner *Scot* was taken into dock in Belfast, cut clean into two parts, and an additional length of 50 feet built into her body amidships. A similar operation was performed on the Hamburg-American liner *Augusta Victoria*.

An incident showing the value of these watertight compartments was that of the steamship

Suevic, which ran upon the rocks off the Lizard on the English coast in 1907. The forward part of the vessel was badly crushed, but the watertight compartments prevented the water from filling the vessel. After the high sea had abated, the rivets of the framework and outer plates were loosened, and, assisted by a blast of dynamite, the *Suevic* was separated into two parts, the forward one third remaining on the rocks, while the after two thirds *proceeded to Liverpool under the vessel's own steam*.



THE "ADRIATIC" AT SEA.



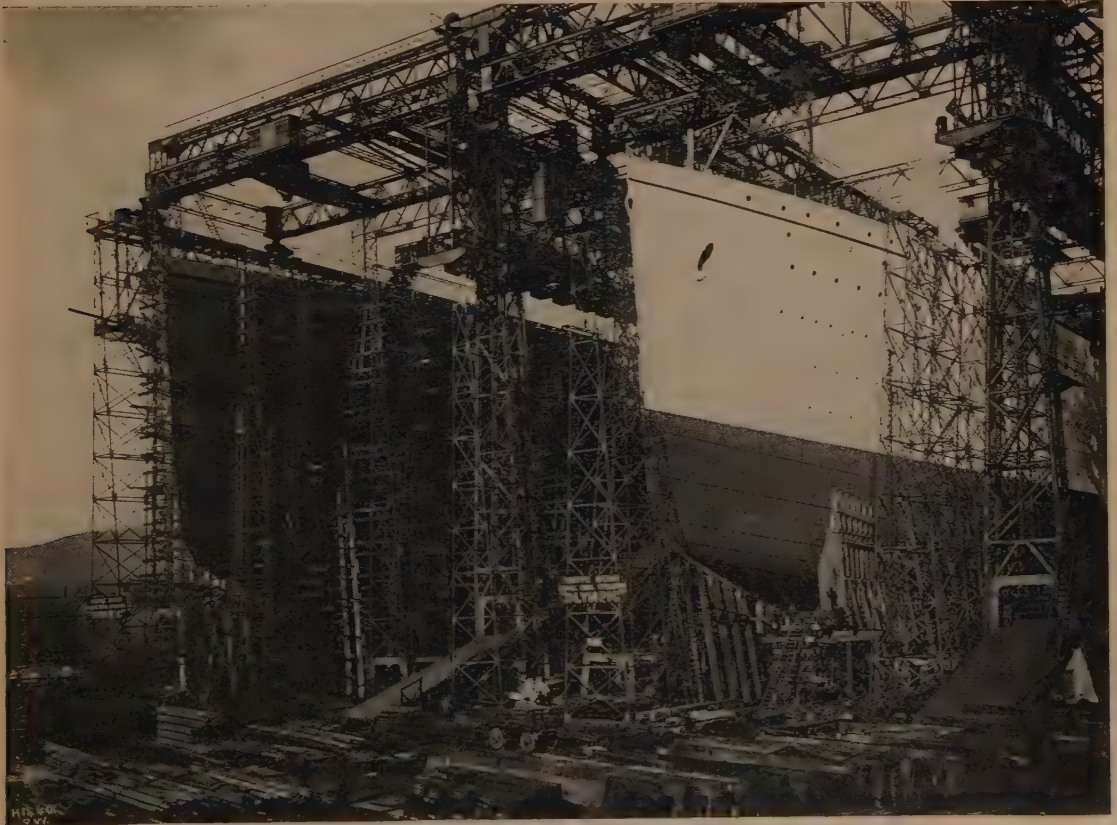
THE STERN OF THE "OLYMPIC," SHOWING THE RUDDER.

THE WORLD'S LARGEST STEAMER

THE White Star liner *Olympic*, christened by the Countess of Aberdeen, wife of the Viceroy of

into the water as gracefully as would a small launch. The boat contains many radical improvements, and provides for twenty-five hun-

Ireland, was launched at Belfast on the 20th of October, 1910. No other boat ever launched has attracted so much public attention, not only because she is the largest vessel that has ever been built, but because her machinery is of a type considerably different from that of previous steamers. Though her launching weight of twenty-seven thousand tons, the heaviest weight ever transferred by man from land to water, gave rise to greater anxiety than is usual in such an operation, all plans worked to perfection, and she glided



THE TWIN STEAMERS "OLYMPIC" AND "TITANIC," IN THEIR CRADLES OF STEEL AT BELFAST.

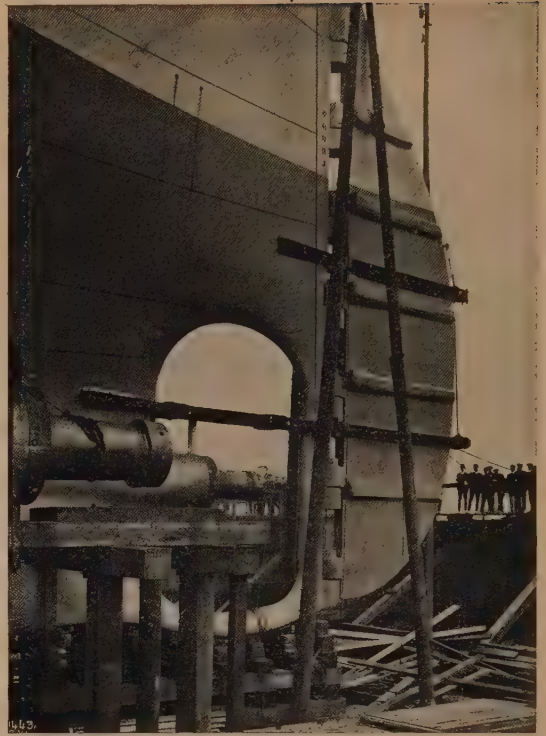
dred passengers, while the crew numbers nearly a thousand men! Her mighty engines are of forty-five thousand horse-power, and are of two kinds, known to engineers as the reciprocating and the turbine.

This huge *Olympic* in general appearance resembles the *Mauretania* and the *Lusitania*, built not long before.

It may help us to realize the *Olympic's* great length of eight hundred and eighty-two and one half feet if we compare it to the Metropolitan Tower in New York, above which, if set up on end, she would extend one hundred and eighty-two feet. She is twice as long as the height of the dome of St. Peter's at Rome, and equals in length the total drop of the famous Bridal Veil Fall in the Yosemite Valley. If she and her sister ship, the *Titanic*, were placed end to end under Brooklyn Bridge, they would completely block the East River and extend one hundred feet over each shore. It is also interesting to note that the length of this immense ship is four times the height of Bunker Hill Monument.

Since the advent of the *Great Eastern* in 1858 no steamer has created such general interest as the *Olympic*, not only on account of her surpassing size, but also because of the immense forward steps thus marked in other lines of marine accomplishment, the outcome of many centuries of conflict with the sea.

In both the *Olympic* and the *Titanic* three million steel rivets, weighing in all 1200 tons, have been employed to bind the massive steel plates, insuring the greatest stability; and the rudder of each vessel weighs 100 tons, yet will be moved by electricity almost as lightly as a feather.



A NEAR VIEW OF THE RUDDER.

Because of the enormous size of the ships, the accommodations, both as regards the several public apartments, including tennis-courts, sun-parlors, swimming-pools, etc., and the passenger staterooms, are exceptionally spacious, while the beauty and luxury of the appointments surpass anything of the kind heretofore attempted.



THE "OLYMPIC" AFTER THE LAUNCHING.



NATURE GIANTS THAT MAN HAS CONQUERED

BY RAYMOND PERRY

MANY centuries ago man's achievements were limited by the strength of his body, because he did not know how to make the forces of nature work for him. He knew that "these forces existed. The wind, the rain, the lightning, all seemed to him the acts of great giants of the earth and sky—or even strange, powerful gods whom he worshiped through fear.

Ages passed before man learned that these forces were as willing to work for as against him, if only he could learn the secrets of control.

The history of the world is largely the story of how man has obtained increasing mastery over these nature giants and used their powers in the tasks of progress.

Wind is the first nature giant that man tamed to his use. Probably, from seeing a tree swayed by this mighty power, man came, at last, to reason that if the tree was aboard a boat, the boat would move in the direction of the wind; so he made a mast from a tree-trunk, and rigged up some rude sail from skins of animals, to take the place of leaves, and found that he could go much faster and farther than with his paddle alone. Gradually, then, he learned also, by means of "tacking," to sail in any desired direction, no matter which way the wind blew. Thus he had discovered the principle used by every sailing-vessel since. Later, he devised the windmill for grinding grain and drawing water. The kite makes use of the wind power and has suggested the aeroplane which man has now made possible through later discoveries. The vacuum cleaner is another way in which the power of air in motion is used. As yet, man cannot perfectly control the wind giant, for cyclones sometimes do great damage on land and sea; but even this occasional danger may yet be subdued.



NATURE GIANTS THAT MAN HAS CONQUERED

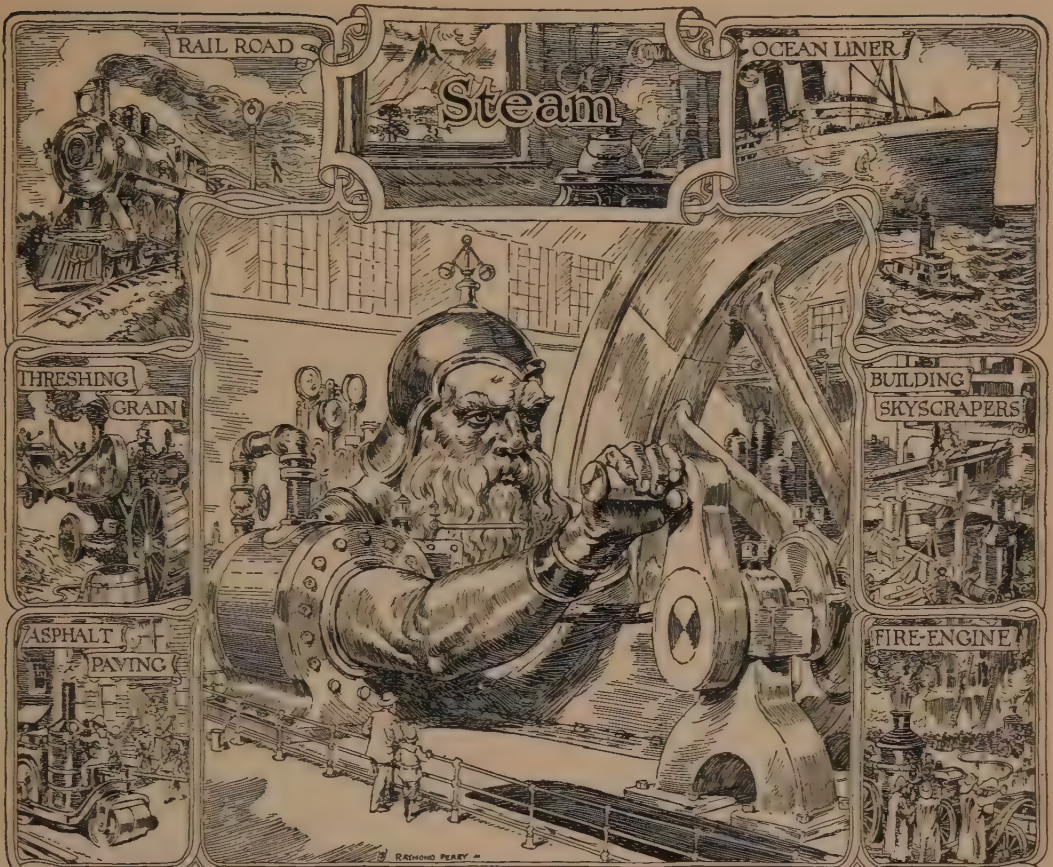
BY RAYMOND PERRY

GIANT NO. 2—WATER-POWER

ONE of the greatest giants that man has tamed is the Wind. The second nature giant that man learned to control was the power of flowing water. We all know that water rises from the ocean as vapor and, dropping as rain on the mountains, makes its way in rivers to the ocean again. The explanation is simple enough, but when we see a mighty waterfall like Niagara, we realize at once that we are in the presence of a powerful giant who can do the work of armies for us, if properly harnessed. But it was long before man learned how to do this.

Up to that time each one had to grind his own grain, a little at a time, by rolling it between two flat stones; but when he learned the use of the water-wheel, he was able to grind with larger stones, such as he himself could not even move, and produce enough meal for his own use and a whole village besides. And now, to crown all, we have the turbine, which takes vastly greater power from the passing water.

The manufacturing industries have made our country famous the world over, and the giant water-force is doing its full share in turning the wheels. We can also see the power of water in use in a canal-lock by means of which a boat may be taken uphill; and in hydraulic mining where it digs the dirt and washes out the gold at the same time. The modern systems of sanitary plumbing, safeguarding the health, and of irrigation, by means of which vast tracts of desert lands are made to bloom, both depend upon the power of falling water.



GIANT NO. 3—STEAM

One of the most famous nature giants is the power of steam as seen, for instance, in volcanoes like Mount Vesuvius. Ocean water finds its way, through fissures in the sea-bottom, down into the heated caverns, and is there converted into steam, which escapes through the crater of the volcano, carrying with it molten rock and gases. Herculaneum and Pompeii are two cities buried centuries ago by such eruptions. Earth-

quakes and tidal waves are also due to the power of steam convulsing the regions far below the earth's surface. Watt, an Englishman, first discovered the power of steam by noticing that the cover of his mother's boiling tea-kettle was frequently pushed up by the steam in its effort to get out. This resulted in his making the first steam-engine. Since Watt made the first engine, improvements have been made in all its parts, such as flues in the boiler, safety-valves, governors, and devices to save the power yet remaining in steam already partially used. To-day we have the swift locomotives drawing palatial passenger-trains from coast to coast, the powerful "Mogul" engines for long freight-trains, and the massive stationary engines for factory use. On the sea great ocean liners are making new speed-records every year. Threshing is done by steam-machinery, and in the city the steam-roller helps to pave the streets, the steam-hoist helps to build steam-heated sky-scrapers, and steam fire-engines protect the lives within these buildings. It may seem strange, but it is this same hot steam that gives us cooling drinks, cooled theaters, and even skating in summer by operating steam-engines that drive powerful ice-making machines.



NATURE GIANTS THAT MAN HAS CONQUERED

BY RAYMOND PERRY

GIANT NO. 4—THE EXPLOSIVE

THE fairy story of a large and powerful genie confined in a small jar, is no more wonderful than is the true story of a bit of powder packed in a cartridge; when the powder is exploded, it propels the bullet far and with terrific speed. A Chinaman first discovered the power of explosives when he invented gunpowder, and it has proved to be the greatest of all the forces that have changed the maps of nations. Explosives so powerful have been discovered now that no gun can be made strong enough to be discharged more than a comparatively small number of times; and there are machine-guns, submarine mines, and torpedoes—engines of destruction so powerful that no battle, either on land or sea, could last more than a few hours. Indeed, it is predicted that soon no two nations will dare to go to war, so terrible would be the consequences to themselves and to the rest of the world.

While explosives are needed less and less for war than formerly, they are used more and more in the victories of peace. When the genie was let out of the jar, he built great palaces for his master and transported him great distances by land, by sea, and in the air; and that is just what the Giant Explosive is doing to-day for man, his master. The power of dynamite is blasting rock for the foundations of sky-scrapers and bridge piers, and boring tunnels through the solid mountain; while gasoline, the new explosive, is used for transportation, in automobiles on land, in motor-boats in the water, and in aeroplanes in the air; thus finally accomplishing the dream that man has cherished for centuries,—the marvel of human flight.



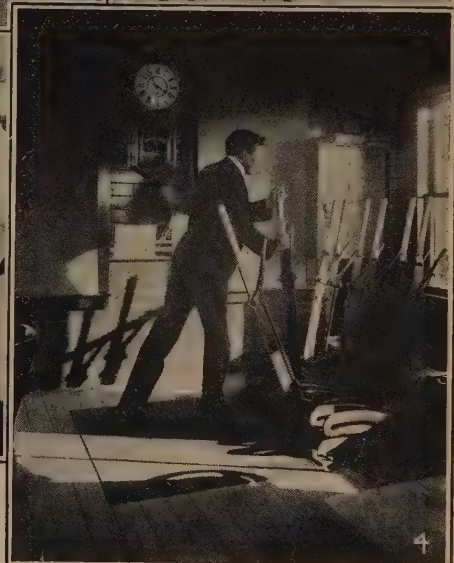
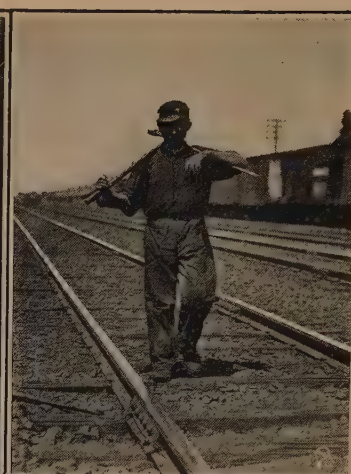
NATURE GIANTS THAT MAN HAS CONQUERED

BY RAYMOND PERRY

GIANT NO. 5—ELECTRICITY

Of all the nature giants that man has conquered, Electricity is the most mysterious and interesting. Lightning is Electricity revealing himself in nature, as though he were calling to man, "See, I am all about you, anxious to be used; come and take me!"

And so he has been impatiently calling to man from the most ancient times, but has always been misunderstood and neglected until lately. Electricity is a big, noisy giant at large, and badly spoiled, for he wants lots of coaxing and petting; but treat him rightly and he settles down to his work as amiably as you please. You can hear him humming to himself in the big dynamo power-house, where he sends out the currents that drive the trolley-cars, and those that light the streets and houses through innumerable arc and incandescent lamps. Every American boy may feel proud that America has always led the world in the subjugation of Electricity. Franklin's experiments opened up the possibilities, and other Americans have been developing them ever since. Morse invented the telegraph and Bell the telephone, and their use has brought the people of the earth closer together. By taking advantage of the invisible lines of electric conductors in the air—the ether, rarer even than the air itself—we have been enabled to telephone and telegraph without wires. Already hundreds of lives have been saved through messages sent from or to ships at sea. When the boys of to-day are grown-ups they will probably look back upon the present as but the beginning of the wonders promised to humanity by the giant Electricity.



1. THE CONDUCTOR AND THE TRAINMAN. 2. THE TRACK-HAND. 3. THE STATION-AGENT. 4. THE SIGNAL-TOWER OPERATOR. 5. THE ENGINEER. 6. THE BRAKEMAN.

THE GREAT WONDER OF A RAILWAY TRAIN

You must have stood some day in a country road, perhaps in a quiet place far from any town, and watched a train rush past. There is really nothing in the world more thrilling to see than that, especially if it is dark, and the train flies past in a flood of light, like a giant who possesses the earth. That train started from a great city; it flies through towns and villages, past fiery furnaces and smoky factories, through quiet fields where cattle are grazing and birds are singing, on into another busy city that lies ahead.

This wonder of the world, the railway train, is one of the greatest triumphs of man. It began with a kettle steaming on the hob—with a man who started thinking for himself about the steam, and wondering what could be done with it. That thinking man has changed the world for you and me, and when we go to the seaside for our holiday, or come to New York to see the great stores, or go from town to town to see our friends, we owe our pleasure very largely to a man who sat by the fire a hundred years ago watching a kettle steam.

Perhaps you have not thought, when quietly sitting in a railway carriage, that you can be safe and happy at such a time only because thousands of men are wide awake and looking after you. It is not enough for the driver to be always looking out; it is not enough for the fireman to keep the fires burning. If nobody did anything else than that, we should never get anywhere at all, and no railway would be safe. The men in the signal-boxes must attend to the signals. The track-walkers must see that the line is safe. The man at the switch where the lines join must see that the switch is properly set. The man who makes the time-tables must see that two trains are not at the same place at the same time. The men in the station must be ready for the train when it stops. Somebody must see that the tunnels are free, that the bridges are safe, that there is water for the engine when it is wanted. Every bit of every railway should be examined every day.

And so hundreds of thousands of men are kept busy all day long, watchful every moment, listening, thinking, writing, telephoning, running, shouting, working at a hundred things, in order that we may ride comfortably in the train.

A hundred years ago there was not a single train in the world, and there are still many old

people who have never been in a train. There are some people who have never *seen* a train. The railway is yet young, but it has grown quickly because it is the first thing that men need when a country begins to grow. Thousands of trains are always running, carrying thousands of people to and fro, and it is a wonderful thing to think that the power which drives them is the same power that makes a violet grow. If there were no sun there would be no trains, because there would be no fuel; and if there were no fuel there would be no steam to drive the giant engines on their way.

THE RUNNING OF A TRAIN

WHEN railways were new, as many a man still living distinctly remembers, a train could not be stopped unless a brakeman on each car put on the brakes with his utmost strength by turning a little wheel like those that are still kept near the platform-rail. So, when coming near a station, the engineer would blow a signal, the brakeman on each car, using all his strength, would put on the brakes by hand, and gradually the train would stop, often with a bump that threw the passengers forward in their seats.

To-day, all brakes are moved simply by turning a little handle in the engineer's cab. This is done by having the brakes drawn against the wheels by powerful springs, then pushed away by air compressed in tubes underneath the car. The air-pressure is kept on to hold brakes from the wheels until necessary to slow or stop the train. Then the engineer, turning the little handle, lets the air out of the tubes, the springs set the brakes gradually as the air escapes, and the train comes gradually to a standstill without jarring.

This gives quick and sure control of a train, no matter how heavy. It is also the greatest safeguard against accidents caused by trains breaking apart. As the cars separate, the air-tube also parts, its air escapes, and the brakes are set, bringing car and train to a standstill.

Early trains were wasteful of power. Once the steam used to drive the wheel escaped into the air. Now the steam is used first in a large cylinder, then escapes to a smaller one, where it is used again and so does much more work with less waste of fuel.



1. CONSTRUCTION
WORK ACROSS
A CLIFF.



2. SIGNAL - TOWER
(SHOWING PIPE-
RODS FOR CON-
NECTING SIGNALS
AND SWITCHES).

3. MOUNTAIN ENGINEERING (KICKING HORSE CAÑON, C. P. R. R.).

3

4. JUNCTION PROTECTED BY SEMAPHORES INTERLOCKED WITH SWITCHES.

4

The burning of coal is much hastened by having mechanical ways of blowing the fire, instead of depending only upon the draft from the smokestack. So the old big high smokestacks, no longer useful, are replaced by small ones which are quite sufficient, because the fire is blown by machinery.

Another valuable improvement of recent years is that which permits officials of a road to talk with trainmen while the train is in motion. This is done by electricity taken from the wires running along the track, conducted within the car, and used in telephoning or telegraphing.

Something has been said already of modern signals to safeguard tracks, but these are of so many kinds and so wonderful in construction that great volumes would be necessary to explain the different kinds.

RAILWAY DISCIPLINE

RAILWAY management has become a science and an art only to be understood by men who spend their lives in learning some of the branches. Yet the whole force of railway men is under discipline like an army, divided into different departments, each with its officers and workers, and all responsible to the few managers at the top of the system. Even the mere business bookkeeping, to show what is done with every cent of

money expended, with every bit of property, and so on, requires an army of clerks, and forms a vast business in itself.

Before anything is done outdoors, whether it be the running of a train, the building of a bridge, or the opening of a new station, every bit of the work must be foreseen, planned, and arranged for by engineers, drawers of plans, and accountants. Even the time-tables by which each of us knows just when to expect the train he wishes to take, is the result of hours upon hours of careful work done in order that each train may have its own schedule, each station the stops to which it is entitled, each business house a chance to use the freight-cars it may need, and all so planned that none of the hurrying trains shall, if all goes well, interfere with one another. All this is planned out on a great board, by the use of pegs and strings, so that the diagram will show just where each train is to avoid every other. Putting on a single extra train requires sometimes the upsetting of the carefully arranged plan.

Little boys sometimes are filled with admiration and wonder when they see the engineer driving a great locomotive. But though it seems more romantic, the engineer's work does not compare in difficulty with that of many a quiet worker in the railway offices, whose day is spent in studying figures or handling plans and drawings.

RUNNING THE FAST EXPRESSES

BY GEORGE ETHELBERT WALSH

WHEN the Twentieth Century Limited, or some other fast railway-train, rushes across the country at the rate of seventy miles an hour, making mile-posts and trees skip by in fantastic disorder, the mind of many a passenger is troubled by a question that continually arises at every sharp sway or jolt of the cars: "Is there not danger in such rapid traveling?"

In his seat forward the engineer would reply grimly to this question with a negative shake of the head; and the general superintendent of the road, or the train-despatcher in his office at headquarters, would second this answer with a more emphatic "No."

But why? According to all the mathematical rules we learned at school and college, the faster a moving body swings along a certain course, the more difficult it is to swerve it from its path, and the more terrible is the collision if it should strike an obstacle.

Why, then, is not rapid running more dangerous than slow? "Because the engines used for this service are larger, better equipped, and better cared for than any others," the engineer would reply. "They are provided with every modern device to prevent accident; and though they fairly fly along the track, they are never beyond our immediate control. And then—we're more wide-awake and alert for danger."

"The danger is less for the reason that everybody along the line is looking out for the rapid fliers," would say the train-despatcher. "They have the right of way, and we always clear the tracks for the expresses. They are special favorites, and we give extra careful attention to them."

For verification of these answers let us follow the two immediately responsible parties in their day's work—the engineer and the train-despatcher.

The former comes down to his post of duty nearly an hour before his train is scheduled to leave. All night long in the roundhouse the engine has been carefully watched; a wiper has spent the whole night rubbing down the panting, snorting iron horse until every rod and cylinder

house men; and if any part is not satisfactory, he makes it so. The engineer makes his inspection after the fireman, and thoroughly and carefully examines every part. All the bearings are then oiled, and the oil-cups are filled with oil. Next, the engine is run out of the roundhouse

and tested. Fifteen minutes before the time to start, the engine is coupled to the train, and the steam- and air-brakes are tested.

No race-horse was ever brought to his post better fitted for running the course than is the locomotive of the fast express. In addition to the tests already made, a mechanic goes from wheel to wheel, and upon every one strikes a sharp, resounding blow to ascertain if the wheel and axle are sound. Nuts and bolts are examined. The engineer and fireman are held responsible for the perfect condition of the engine and cars before the start is made.

When the signal is given to start, the engine is panting under the suppressed power that has been generated in her boilers, but she gives at first a pull so gentle that the train rolls smoothly and noiselessly out of the station. The run is comparatively slow until the city limits are passed, and then the speed is gradually increased, but so imperceptibly that the passengers can hardly tell when they are traveling a mile a minute. The fast fliers have few stops to make, and the high rate of speed is maintained for long periods without interruption.



IN THE ROUNDHOUSE. GROOMING THE ENGINE.

shines like gold or silver; the banked fire has been kept going, so that a little steam has been always in the boxes; and before he left at night the fireman put everything in perfect order inside the cab. The fireman appears first in the morning, and inspects the work of the round-

are on the clock and time-table before him, and he keeps a sharp lookout ahead. For various reasons he may fall a few minutes behindhand at one point, but he manages to make up the loss at another. He has certain stops to make, and he makes all speed possible between them. But



THE FAST EXPRESS. A "FLIER" HAS THE RIGHT OF WAY.

he is not master of the road. At any moment a danger-signal along the line may confront him. He may be ordered to bring his train to a stand-

still at a small way-station, and there receive telegraphic orders to run on a siding. He asks no questions, but obeys orders. Five minutes

later a "special" may rush past him, and then the signals are set again, warning the engineer of the express that he must make up for lost time.



THE ENGINEER ON THE LOOKOUT.

To understand this delay, and the sudden changes made in the time-table, it will be necessary to go back to headquarters and to watch the general superintendent and the train-despatcher. Although many trains running on the line are hundreds of miles away, the

exact position of every one, every second in the hour, is known and recorded. A telegraph-operator is working industriously in the office of the train-despatcher, receiving and sending orders. The running orders of all the trains are directed from this office. Each engineer has orders to make a certain run according to the time-table, unless other orders from headquarters interfere.

If an accident happens on the road, the train-despatcher knows it almost as soon as the passengers. A breakdown of some local train on the main line may upset all the calculations of the day. Immediately the expresses running on that line must be stopped before a collision oc-

curs. A snow-storm may blockade a train on the northern branch of the road, and thereby make necessary a change in the regular schedule.

A train from the West is half an hour behind, perhaps, and this interferes with the regular running of the other trains. Arrangements must be made to let trains pass without accident. The express-trains nearly always have the right of way. A Western express may be behind time, and start out five minutes ahead of some special express. In this instance she must give the special right of way, and she is forced upon some siding. The special express passes without losing a minute.

There are fifty trains coming and going, one behind time, another ahead, probably, and each crowding out another. The train-despatcher has to regulate this tangle and keep things running smoothly. Thus it is that the engineer of a flier may suddenly find himself side-tracked.

Should the train-despatcher make a mistake, or fail to make arrangements for two fast-moving trains, the block-signal system would probably prevent an accident. The block-towers are connected by telegraph-lines, and a bell-code enables the men to communicate directly with each other. They can stop a train at any moment by means of their signals, independently of orders from headquarters. Thus the engineer depends entirely upon others to keep the track clear, and he merely runs his train as near schedule time as possible, and keeps his iron steed in perfect condition.

It is owing to these many safeguards (besides which, of course, the strength of the rails and firmness of the road-bed must be considered) that rapid traveling is made as safe, if not safer, than slow traveling, especially on the best-equipped roads, where every modern device for avoiding accidents is employed.

A WORD ABOUT WIRELESS TELEGRAPHY

BY JOHN M. ELLICOTT, LIEUTENANT U.S.N.

SOME years ago, after a few days' leave, a naval officer went to a certain city, early one morning, to rejoin his ship, and found that she had sailed away. Not knowing where she was bound, he felt very much "at sea," when a friend asked him why he did not telegraph.

Said the friend: "Your ship has been fitted with the wireless telegraph apparatus, and there is a wireless station here."

"Can you call up the *Prairie*?" asked the officer, at the wireless station.

"Oh, yes," was the reply, and the operator tapped off a few loud and luminous sparks on his transmitter. Almost immediately the little wheel at his elbow commenced reeling off its tape with dots and dashes on it.

"Ask the *Prairie* where she is," said the officer, "and inform her captain that I am here waiting to report on board."

The message was quickly sparked on its way, and within three minutes the tape reeled off, in reply:

"The *Prairie* is one hundred and twelve miles at sea, but will return this afternoon."

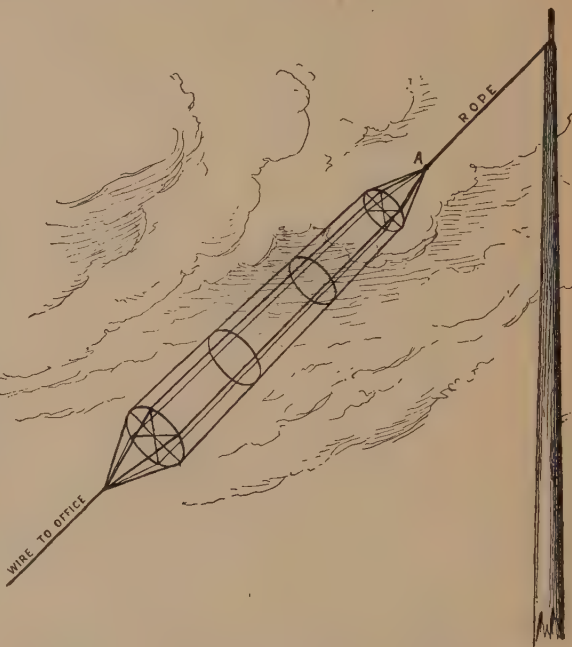
"All right," said the much-relieved officer. "Telegraph her steward to save my lunch."

From the beginning of 1903 experiments with wireless telegraphy between ships at sea and between themselves and the shore were made in the navy. Several systems were tried, under the supervision of a board of naval officers, before one was finally adopted. Stations have been established at various places on shore, and vessels properly equipped for use of the "wireless" in "war-games."

A wireless telegraph system on board ship consists of a dynamo to generate an electrical current; of a special telegraph apparatus to control that current, to break it up into long waves and short waves, and to send these waves through the air until they hit upon the receiving apparatus of another station and make dashes and dots on its receiver; and, finally, of wires from the telegraph apparatus to the masthead of the ship, so that the waves can start from there clear of all obstructions. These waves are spherical in shape and so extend in every direction. They might be compared to huge soap-bubbles that increase in size as they grow out from their source—the greater the distance, the thinner or weaker they become.

And here lies the trouble with wireless telegraphy: that the message goes in all directions. Not only the station for which it was intended will receive the message, but any other station which the message waves may reach before they lose their strength will also receive it. For use in war, that part of the trouble could be overcome by means of a cipher code; but even then an enemy's ship, receiving a message in an unknown cipher, would know that some vessel of the defending squadron was near. The worst part of the trouble caused by the waves going in all directions is that one set will get mixed up with other sets from other sending-stations, just as waves circling away from two or more stones dropped in the water will meet and get jumbled up. If two or more sending-stations try to talk at once, it will be, at the receiving-station, like trying to listen to several conversations at the same time. If one station is saying c-a-t and another d-o-g, the receiving-station may get c-d-a-o-t-g, or the waves may overlap so as to turn dots into dashes and make no letters at all. So, again, an enemy's vessel, approaching a coast and hearing on his "wireless" a defending scout trying to tell of his coming, can break in on the message merely by continuously repeating a single letter, and make the in-

formation completely unintelligible. It is said that this may be overcome by having the instruments, so to speak, "tuned up" differently from those of the enemy, so that the waves sent out



SKETCH SHOWING HOW THE WIRE IS FASTENED TO THE MASTHEAD.

would not fit his receiver, and *vice versa*; but even then the enemy could probably, by "tuning" his instrument up or down, strike the proper key and accomplish his interference.

Sometimes other electrical connections in a ship get mixed up with the wireless telegraph. On a certain vessel in the navy, newly equipped with "wireless," there were electrical connections to her pilot-house to show the revolutions of the engine and also the speed registered by the taffrail-log. As soon as the vessel got under way a most garrulous conversation began over the "wireless" between the propeller and the taffrail-log. No doubt the propeller was quarreling with the log for not telling the truth about the speed.

The distance to which a wireless message can be sent is chiefly a question of the strength of the electrical current generated and sent out, and instruments are manufactured for different strengths according to the distance over which they are intended to be operated; but an instrument powerful enough to carry, say one hundred miles can be adjusted to a radius of only ten or fifteen miles, and to intermediate distances.

Here, again, an enemy might introduce serious interference, for it is said to be possible that an apparatus adjusted for short distances can be burned out or seriously deranged by receiving

ment, with its usual enterprise, is alive to this. Wireless telegraphy undoubtedly came into the navy to stay, and has grown in usefulness and importance. Its commercial application over the

U S S P N A I N I E

A WIRELESS CALL.

upon it the waves from another apparatus of much higher power.

Wireless telegraphy has not thus far been very successful overland. Mountains, hills, forests, and tall buildings seem to break up the waves and make them unintelligible. Coast stations are, therefore, established on prominent headlands, where there are no outlying islands to seaward.

These imperfections make wireless telegraphy at present chiefly useful in communicating with isolated places having no other telegraph; but we must remember that when the telegraph and telephone first came into use they were in many

seas is already vast. We have been accustomed to feel that when loved ones went out upon the great deep they passed, for the time being, beyond our knowledge and beyond reach of our sympathy, and became imprisoned in a realm of danger from which no cry for help or assurance of safety could reach us. Now, through this wonderful invention, we may learn their progress from day to day, even from hour to hour. They can tell us of their daily health; they can transact matters of daily business; they can assure us that they are speeding over sunny seas; or they can ask, when in distress, that a vessel be sent to their relief.

W E I S P N I

A JUMBLED WIRELESS MESSAGE.

ways even more imperfect, and their development into the systems of to-day was never even dreamed of.

It is plain to see that the need which nothing but wireless telegraphy can fill is that of communication with vessels at sea. Our govern-

All this is practised now, not only on some of the naval vessels of various nations, but also on many of the great transoceanic passenger liners, and we cannot doubt that the remaining imperfections of wireless telegraphy will be, in time, completely overcome.

THE MARVELOUS TELEPHONE

WHEN we speak a word we make the air move or vibrate; every different word makes the air vibrate in a different way. We call these vibrations air-waves. But an air-wave does not carry sound so far or so fast as electricity, so we use the telephone to change the air-waves into electric waves, which travel along the wire quicker than sound can travel from the tongue to the ear. When we speak into the telephone, a thin iron disk, acting on an electric current, changes the air-waves into electric waves, which travel along the wire to a disk at the other end. At this disk the electric waves become air-waves again, and give off exactly the same sounds as the sounds that first made the waves. These sounds are the words from our lips. Our words strike one disk and become electric waves; the waves strike another disk and become words

again, because both disks vibrate in tune and exactly the same sound is given off by the second disk as is spoken to the first.

It is somewhat strange to think that a teacher of the deaf and dumb should be the one to make the transmission of the human voice possible over thousands of miles, and across continents and channels. Yet it was Professor Alexander Graham Bell, who was such a teacher, that invented the telephone, which, common as it is, for most of us is a great deal of a mystery. The telephone does not merely carry sound a long distance, but carries the human voice, and takes words and laughter over miles and miles.

Think how wonderful it is that a wire should speak words to you! If it made a mere fizzling or crackling noise in your ear, that would not be very wonderful. But this wire says words in

your ear which you can understand; words that have meaning; words that tell you important things. Even here the mystery does not stop. Most wonderful of all is it that the words which come to your ear on the telephone have the very tone of the voice that utters them miles and miles away. You can always tell on a telephone whether it is your father, your mother, your uncle, or your brother who is speaking. You recognize the voice.

How strange, how wonderful is this! Let us see if we can understand it.

If you put your hand before your mouth and speak against it, you will feel warm breath striking against it. If you place a stretched drum-head and talk against it you will feel the vibrations. Our voices, as we have said, set up movements in the air, and these movements are called waves because they move to and fro, somewhat like the surface of the sea, but much more rapidly. We hear people speak because these sound-waves enter our ears and beat against the ear-drums. In the telephone these sound-waves from our mouths are transformed into electric waves that can flow along the wire and then at the other end of the wire become transformed into sound-waves again and enter the ear of our friend in exactly the same manner as the telephone received these sound-waves from our lips.

The wonder is that the message is given off by the wire exactly as the wire received it from our lips. Men have been able to make a machine to do this because they have discovered waves of electricity similar to the waves made in the air by sound. Men can make these electric waves, so that the electric wire which carries our messages is really carrying electric waves, moving to and fro, or vibrating, just like the air-waves made by our voices. But electricity travels very, very rapidly, faster than the voice can travel, so that while the waves may move to and fro just as rapidly, yet the electric waves advance more rapidly and reach their destination earlier. Suppose that the human voice could be heard in Boston from Philadelphia, instead of only a few hundred feet at the most. Well, a message by telephone would get there much more quickly, because electric waves are much more rapid than air-waves. So you see that the telephone wire does not really carry the sound-waves. The wire does not carry such words as *love*, *business*, *health*. No; it carries electric waves. But the man at the other end of the telephone does not hear the fizzing, or the mere whisper, of these waves; he hears words; he hears *love*, *business*,

and *health*—just as if his friend had spoken these words into his ear. How is it?

All that we can say is this: When we speak we make an iron disk vibrate like the stretched drum-head. This iron disk presses against some carbon granules in the nickel-plated case of the telephone transmitter behind the black rubber mouthpiece into which we talk. Through this carbon flows a current of electricity, and this current will be changed as the carbon is pressed and relieved by the rapid movement of the iron disk. Thus electric waves are produced in the live wire. There is an electromagnet at the end of the wire and a little disk of stretched iron which trembles as it is drawn to and from the magnet. Now this drawing to and fro depends upon the varying strength of the electric current due to the electric waves. The vibration of the iron disk produces a trembling of the air exactly like the trembling of the air caused by your voice, and so the iron disk produces the very words you spoke!

That is the explanation; but, if you think hard, you will see that it really does not explain the great mystery of the telephone. It does not tell us how the waves vibrating to and fro along the wire reproduce the exact sound of a voice in New York, with its little laughs and jerks, and make it come from a disk of iron in a room in Baltimore, as if the mouth of the speaker were in that very room.

A great telephone exchange, such as may be seen in a large city, is a wonderful sight. The walls are covered with what are called switchboards. Such boards, for example, enable a boy living in Hartford to talk to a boy in New Haven, and a girl in Boston to speak to a girl in Plymouth. They are very expensive and complicated affairs, and their destruction by fire is a great calamity. Once this happened in Paris, and it was necessary to cable to Chicago and have a switchboard that was constructed for another city sent to France immediately. It was shipped and erected within a few weeks by American workmen, because the factory in which it was made was the only factory that could do the work in a short time, and delay was almost unendurable. The switchboards of a large central station are filled with tiny holes like honeycomb, each bearing a number, and over them are dull glass knobs no bigger than a shoe-button, also having numbers. In front of these boards sit the operators, generally young women, who must have good hearing and be very quick, and should be free from nervousness.

At their ears the operators have receivers (the receiver is the part of the telephone that gives

off a message), and just under the operator's lips is a transmitter—the part of the telephone that sends a message. The receiver fits over the head, and the transmitter is placed directly in front of the operator, whose hands have to be quite free, as they are very busy.

When a man in his house or his office lifts the receiver of his telephone off its hook, one of the knobs of dull glass on the switchboard instantly lights up. Once we had the crank of a small magneto-generator to produce the current to ring a bell at the central office. But now in a city system the operator sees the light, looks at the number under it, and puts a plug into one of the holes in the honeycomb bearing the same number. The central operator then answers the caller, for as soon as the plug is put in, he is connected with the exchange. He tells the operator what number he wants. As quick as lightning she lifts another plug joined to the first one, and puts it into the hole bearing that number. When she does this a bell rings in the office or room to which the number belongs, the tenant takes up his telephone and speaks directly with the person who has called him up. When they have finished talking, and put down their telephones, the little light goes out, and the operator removes the plugs. They are then "cut off."

This is the business of a telephone central office. It is wonderful to see how quietly everything is done. There is no noise, no excitement, but the nimble fingers of the young women are moving quickly under the watchful eye of the chief operator. Although the little "glow-worms" are bobbing in and out on the switchboard all day long, it is so still that you could almost hear a pin drop on the floor.

The chain of operations in telephoning, as most of us now use the telephone, is not so simple as once it was. We daily talk to many more persons than are on the switchboard of one exchange; in fact, in any large city we are connected every day with many exchanges. The operator repeats our call to the next exchange, and the electricity travels along the trunk wires as they are joined to connect the two persons desiring to converse. But we go much further. We do not confine ourselves to a single town or city. We can telephone about all our immediate neighborhood and its suburbs; in fact, almost across the continent; and conversations from New York to Denver have been possible for some years.

Here again the quick-witted operator helps us. A man in Boston wishes to talk with a business friend in Chicago. He does not know his telephone number, only the address of his street or

office. He calls up the long-distance operator, who has on her desk telephone directories of all the great cities and the country lines, and gives his friend's name. Soon his bell rings, and the long-distance operator reports that his friend has been called to the telephone in Chicago, and that the line is clear for conversation. Indeed, some large business houses have such lines for a certain time each day; or, they may have a private wire, but this is very expensive, as there must be two wires to form a metallic circuit, and these wires must be of pure copper and heavy, so that the electric current will flow readily.

Now, if there is a sleet-storm, the wires may become loaded with ice and break under the strain. But this will not interfere with the wires underground in our large cities, or those that are placed in conduits underground alongside of railway tracks or the highway. Instead of two wires, we can use many pairs of wires insulated from each other by paper or rubber, and form them into a cable which may be drawn through a pipe or through the hole in a conduit. But the electric waves do not flow so readily along the wires in a cable, so we have to employ devices to make their passage easier; and when we have a long underground line we insert at regular distances small coils of wire which have the effect of strengthening the current. This is the reason why we cannot talk across the Atlantic ocean, for the electric waves corresponding to the voice are very different in their rapidity and nature from those sent along by the telegraph operator in the cable-office. But the loading coils have been used with submarine cables up to 100 miles or so with success, and some day we may have a cable through which electric impulse will pass with sufficient strength to be reproduced at the other end in the form of sound.

So necessary is our telephone that every one who can must have an instrument in his house or office, and usually on his desk. So many telephones are in use in the United States that there is an instrument to every fifteen persons. Even the farmer must have his telephone, and if there is not a company in his neighborhood, he will unite with his neighbors to maintain coöperative lines. Sometimes he even uses his wire fences for conductors in place of the wires on the familiar poles.

Yes, the telephone makes everybody neighbors, and saves much time that often is valuable, as in case of illness or fire. In England the telephone is a part of the post-office, but in the United States it is maintained by private companies, and sometimes there are two in the same city.



THE EIGER.

THE MÖNCH.

THE JUNGFRAU TUNNEL

BY F. W. WENDT

"Yes, pretty rough trip," Uncle Tom called back, leaning over the railing of the steamer that had brought him home again. And in truth it must have been; for when May and Harry, standing on the pier, looked up at the huge black funnels, they saw large white salt-patches clinging to the very top, showing that the ocean had climbed away up there.

On the evening of Uncle Tom's arrival, a merry little family party had gathered around the Marston tea-table. The red-shaded lamp in the middle of the table, among steaming biscuits and delicacies of every kind, threw a fine, cheery glow over everything. Even the singing tea-kettle bubbled and chuckled, and danced its little cover up and down in high glee, because Uncle Tom had come home again from Europe. When he came from abroad he always had news and

stories to tell, which May and Harry enjoyed as much as their parents, Dr. and Mrs. Marston.

"Well, Tom, how fares the world on the other side of the Atlantic, and what news can you tell us?" asked Dr. Marston.

"The most interesting novelty I have found is a plan to take a railroad excursion through a tunnel to the very tip-top of Europe amid snow and ice," answered Uncle Tom.

"Whew—w—w!" said Mrs. Marston with a little shiver; "how cold and wet and tiring that must be."

"Not if you go in the grand way proposed by the Swiss engineer, Herr Guyer-Zeller. You get into a comfortable car in the valley, and without the least exertion on your part you slide up, up, up to one of the highest and most beautiful snow-peaks of Switzerland, the Jungfrau Moun-



THE JUNGFRAU.

tain. Around you and below you lies a magical panorama of ice and snow, while in the distance you may see the landmarks of three great nations: Monte Rosa of Italy, Mont Blanc of France, and the Black Forest of Germany."

"Why, you talk just like a guide-book, Uncle Tom!" said May.

"Then I am making a mistake, because guide-books are seldom interesting. First class in geography, stand up. Now, Miss May, I am going to start in by asking questions. Do you remember when we were all at Interlaken two years ago?"

"Oh, yes!" said May; "and the big white mountain, that looked like a piece of sugar, right in the front of the hotel."

"Yes, I see you remember. Only that big mountain, the Jungfrau, is miles away from the hotel, and even at that distance it looks very, very high. It is more than 13,000 feet."

And then Uncle Tom explained to them all how Swiss engineers had thought it would be a great thing to give any one who cared to go a chance to reach a place where snow and ice never melt all the year round, and to look down

from that tremendous height and see what a beautiful world this is.

"Now bring your map of Switzerland, May, and I will show you just where all this is to happen."

"And I am going to help clear away the tea-things. Then we can make believe that the table is Switzerland," said Mrs. Marston, "and Uncle Tom can take us with him and point out places on our make-believe Switzerland."

Uncle Tom went out, and when he came back with a large package of photographs under his arm, he found everything ready for the "trip." The rough, dark-green table-cloth was a fine ground to build upon. Large and small plates were to represent cities, and cups of different sizes were ready to be put into the proper places as snow-covered mountains.

"Ah! here we are," cried Uncle Tom. "Now, ladies and gentlemen, we will take you up higher than you have ever been in your life. All aboard!—we start from Interlaken."

"On the map, you see, Switzerland looks like a large, irregular ink-blot, squeezed in between France, Germany, and Italy. Its boundary-line



ALPINE CLIMBERS.

is very ragged, little tails and legs and fringes sticking out all around. But our green, oblong table will do well enough." Uncle Tom took up two large plates. "Now find Berne and Lucerne on the map, and put the plates on the correct places on the table."

Harry and May, after a little study of the map, laid them in their proper positions. Then they found Interlaken, and marked that site with a small saucer. The three formed a triangle in the middle of Switzerland, with one of the corners, marked by the Interlaken saucer, pointing south.

"That is to show us exactly where we are," said Uncle Tom. "Now below Interlaken we

will place three 'tea-cup mountains.' The one on the right is the Eiger, the next one, to the left, touching it, is the Mönch, and the largest one, to the left of the Mönch, is the Jungfrau.

"A train leaves Interlaken early in the morning and takes us through the beautiful Lauterbrunnen valley. Then we have to change cars and get into a funny little combination composed of one car and a small locomotive. This strange train pushes and puffs up the steep incline with us, and gives us a fine view of the mountains—the Eiger, Mönch, and Jungfrau—the mountains which are to be pierced by the great tunnel through which the ascent is to be made.

"Every minute the scenery changes. The river below and the chalets grow smaller and smaller, and finally, as we look down, appear like Noah's-ark villages.

"We have reached Scheidegg, the last station at present, and the beginning of the great railway that is to be built. We are very high, about 6300 feet, but as yet we seem to be only at the foot of the three mighty mountains that you can see in this large picture. The one farthest to the left is the Eiger, where the tunnel is to begin. Then comes the Mönch, and the largest one on the right is the Jungfrau. Here also is the plan that shows you exactly what the engineers are going to do."

Uncle Tom placed a tracing beside the photograph. "Do you see that dotted line?" he asked. "That is how the tunnel is going to be built. Where it begins on the left is the farthest point you can now reach by rail—Station Scheidegg, as I have told you.

"One day I walked up toward the point where the engineers propose to begin the tunneling. Pickaxes and powder and dynamite will slowly march ahead of them and open the passage for present and future generations. First into the very heart of the Eiger mountain; then, after a sharp right-turn, through the next mountain, the Mönch; still on, under the glaciers and ice and snow fields, to the center of the Jungfrau, to within about 200 feet of the top, directly under the highest peak. A large circular shaft will be run vertically from here to the summit. There will be steps going up this shaft, but as two hundred feet is a pretty long climb by means of a stairway, a large elevator will shoot up and down, and whirl people from the dark interior of a mountain into the dazzling sunlight of the most heavenly Swiss panorama."

"Why, that is like 'Arabian Nights' and 'Aladdin'!" exclaimed May.

"You are quite right, May; people do things now that seem more incredible than the feats

accomplished by the slave of Aladdin's Wonderful Lamp," said Uncle Tom.

Harry had been thinking and wondering. He was a bright lad, and always wanted to know the why and wherefore of things.

"How long is that whole tunnel going to be?" he finally asked.

"Over six miles."

"And the train goes uphill under ground all the time, does n't it; and has to go very slowly?"

"Yes."

"Then," said Harry, "I don't think I would like to creep around in darkness, inside of a mountain, like that, and not see a thing."

"You are right, my boy; but it will not be necessary. Every fifteen minutes there will be a large, roomy station, with great windows cut into the mountainside, from which there will be a view of fairyland even before you get to the tip-top. And nobody will be asked to go on to the end unless he likes.

"Now, I am going to show you how people used to, and still do, climb to the top of the Jungfrau." Uncle Tom drew out other pictures—pictures of snow and ice with a few persons climbing up across the crevasses. "One wrong step," said Uncle Tom, "and they go shooting down thousands of feet. But not only that: the exposure and the cold are terrible, and many people have, as a result, lost their lives. It takes several days to make the perilous ascent and descent, and only experienced and hardy mountain-climbers, with the aid of skilled guides, dare attempt it.

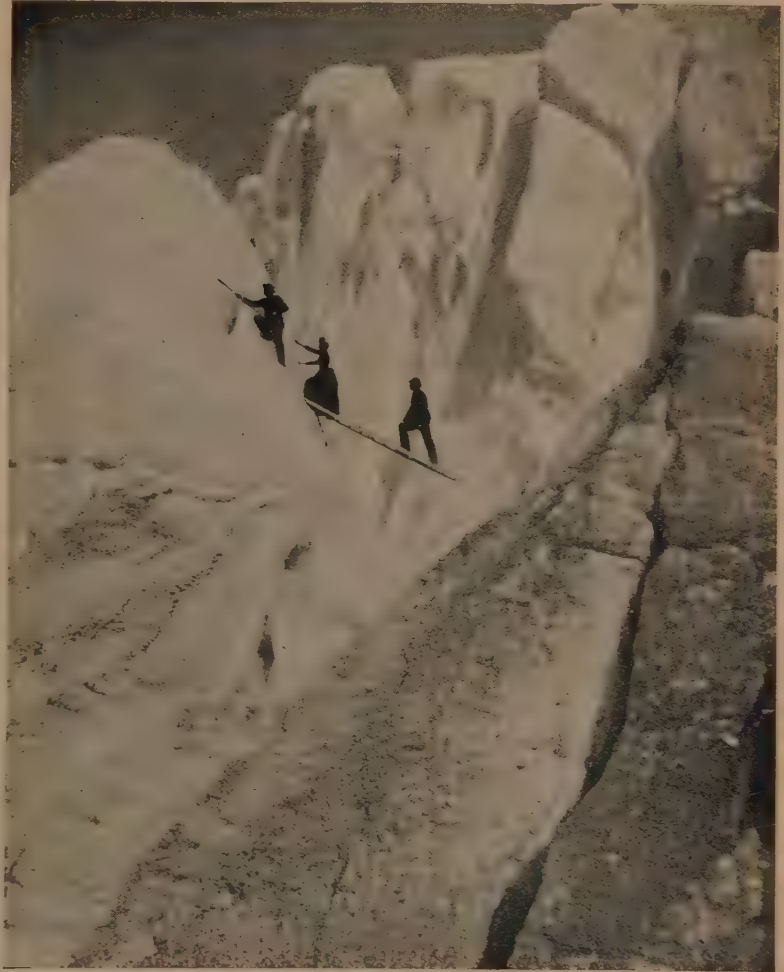
"And now see how all changes when the railroad is built: One takes a comfortable seat in a car driven by electricity, and in a short time is carried to view a panorama that few, until then, have ever seen or dreamed of."

Uncle Tom paused. Dr. Marston was blowing large rings of smoke from his cigar.

"Well, Tom," he said, "that is all very beautiful, but it is not practicable."

"Why not?"

"Because, in the first place, anybody who suddenly rises to that altitude, more than 13,000



HOW THE MOUNTAINS ARE CLIMBED TO-DAY. CROSSING A CREVASSE.

feet, would become very ill through the change in the air-pressure."

"Yes, most people would become ill if they climbed up, but not if they were carried up. It is not only the rarefied air that affects them, but the exertion of the climb uses up the oxygen in the blood, and that of course makes people more susceptible and ill."

"How can you prove that?" asked Dr. Mars-

ton. "No one has ever been taken up there yet without climbing."

"No," said Uncle Tom; "we can only reason it out; a very ingenious experiment has been made with guinea-pigs."

"With guinea-pigs!" called out little May. "Is n't that funny?"

Then Uncle Tom told the children how scientific men had proved by means of animals that the sickness that overcomes most people at great heights is due as much to exertion as to the alti-

light the air under the jar is at any moment by the instrument connected with it." So saying, Uncle Tom showed a picture of the apparatus.

"It looks like a thermometer," said May.

"It does; and it is a similar instrument, called a 'manometer,' or measurer of the pressure of gases, such as air. Under the jar there is a wheel, like the wheels that we have seen squirrels play in. By means of electricity they can make this wheel revolve slowly or quickly.

"And now our experiment begins. We put



THE JUNGFRAU, FROM THE RÜGEN, NEAR INTERLAKEN.

tude. Guinea-pigs were chosen to experiment upon; and as it would have been difficult actually to take them up the Jungfrau Mountain, a very clever scheme was found to produce the same conditions.

"Air, light as it may seem, weighs fifteen pounds a square inch at the level of the sea. The higher we rise the lighter or more rarefied it becomes. This we must fully comprehend to understand the experiment. To begin with, we shall need a large glass bell-jar, one from which the air can be pumped. We can tell exactly how

two guinea-pigs, called 'John' and 'Jim,' under the glass jar. John, however, is placed in the wheel, while Jim is allowed to lie down quietly wherever he pleases under the jar. We then start the wheel going in the direction of the hands of a clock, and so if John does not move his legs and walk forward, the wheel by its motion carries him backward and up. So poor guinea-pig John has to trot forward as fast as the wheel-floor under him moves backward. We know exactly the size of the circumference, and by a sort of cyclometer we can tell how far we

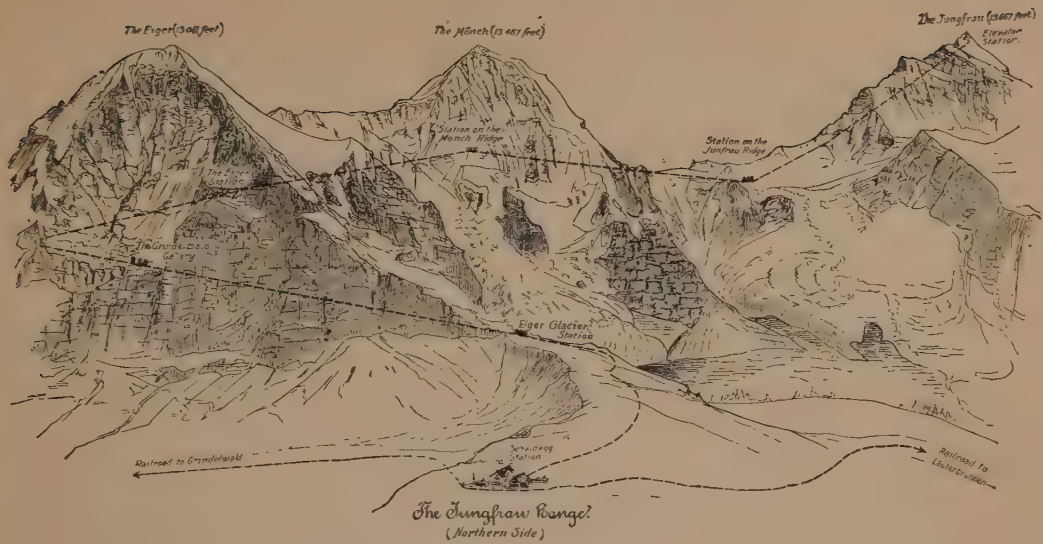


DIAGRAM OF THE JUNGFRAU RAILROAD.

have made John run in the wheel. By slowly pumping out air at the same time, we produce the same conditions as if John were running up a mountain—up the Jungfrau. As soon as the air becomes as light as it would be on a mountain 12,000 feet high, poor John begins to show signs of weariness, and when we keep on and make him go higher still, to 14,000 feet altitude, he falls on his back and is no longer able to move. Jim, on the contrary, in the same light atmosphere, is quite well, as he has made no exertion. If, however, we go on rarefying the air until it is as if at the altitude of the Himalaya mountains, 24,000 feet, Jim too succumbs.

"This little experiment proves that a living being carried up to a reasonable height will suffer little discomfort, while the one who climbed to that altitude will in most cases become ill. If a human John climbs up the Jungfrau around the outside through snow and ice, and a human Jim rides up comfortably through the great proposed tunnel, Jim

will very probably have a good time and enjoy the view when he gets to the top, while poor

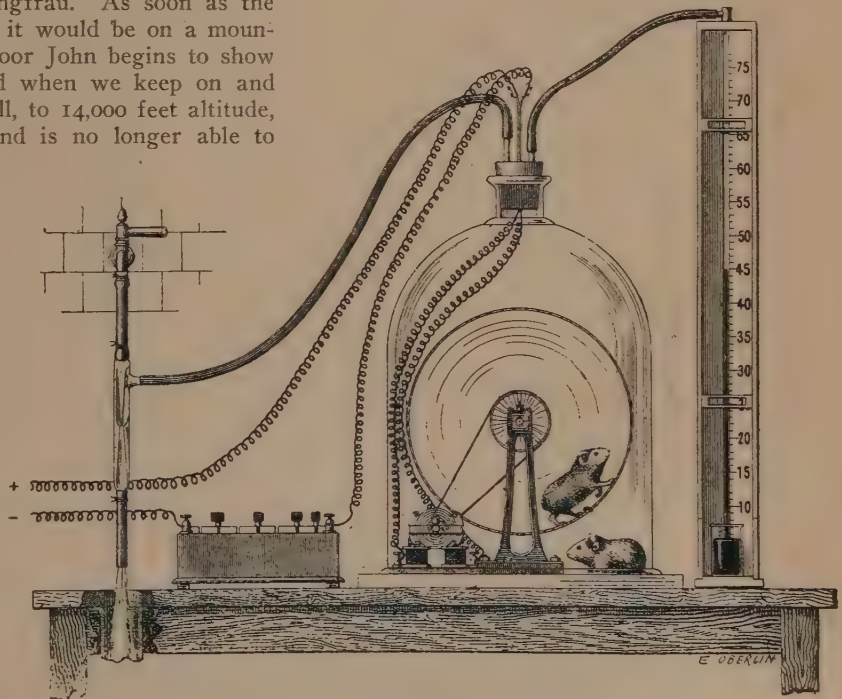


DIAGRAM OF THE EXPERIMENT WITH THE GUINEA-PIGS.

John will feel exhausted and ill—'mountain-sick,' as it is called."

"It seems to me," said Mrs. Marston, "that your tunnel and railroad will do much to drive the poetry out of the Swiss mountains."



DIAGRAM OF THE SPIRAL STAIRCASE AND ELEVATORS TO THE SUMMIT OF THE JUNGFAU.

"Perhaps, for the very few who are able to climb up by means of the alpenstock, that is true," agreed Uncle Tom; "but it will create poetry and show the sublime in nature to thousands of men and women and children who cannot and dare not go there now."

The cheerful fire in one corner of the room had gone on crackling all the evening, unmindful of the fact that the family were away with Uncle Tom on their make-believe trip to Switzerland. May alone had gone to keep it company, and sat upon the polar-bear skin in front of the old-fashioned hearth, staring into the fire, where, she had declared, the logs looked exactly like the Jungfrau Mountain shown in the photograph.

Suddenly the great, tall clock in the corner of the room struck eleven. The familiar sound brought Uncle Tom and his party back from the top of the Jungfrau to the cozy dining-room—all but May. May's curly little head was resting upon the thick bearskin; she had traveled farther than any of them—for she had made the journey to Dreamland.

THE SIMPLON TUNNEL

THE story of the boring of the famous tunnels through the Alps is like a fairy tale. There are three of these tunnels—the St. Gotthard, the Mont Cenis, and the Simplon—and through them, every day, hundreds of travelers pass out of Switzerland into Italy, beneath the Alps, in the very heart of the greatest mountains in Europe, with millions of tons of earth stretching for more than a mile between them and the sky.

Let us take one of these tunnels only—the Simplon. The work occupied 10,000 men nearly eight years, and cost over \$15,000,000. And so the dream of ages was realized—to get quickly, at this point, from one side of the Alps to the other. When Hannibal crossed the Alps with his marvelous army, it took him fifteen days, and cost an enormous number of lives. Napoleon took five days to cross when he set out to conquer Italy. He did not forget the dangers and difficulties of the crossing, but when he became emperor he built the Simplon Road—an extraordinary road running along the Simplon Pass, over a shoulder of the mountain, and rising to a height of 6600 feet. It is 41 miles long; it is

carried over 600 bridges, through many galleries and short tunnels cut in the rock, or built of solid masonry to protect the traveler from the swift rush of avalanches in winter. The work lasted six years, and cost more than \$3,000,000. Until the opening of the Simplon Tunnel, the Simplon Road was the only way over the Alps at this point. The Alps are pierced by two other famous tunnels—the Mont Cenis and the St. Gotthard—but they are far away from the Simplon.

There are two features in which the Simplon Tunnel differs from all others. Being $12\frac{1}{4}$ miles in length, it is more than three miles longer than any other tunnel in the world. A more remarkable point is the immense distance beneath the surface at which it runs. When we reach the highest point to which the tunnel climbs in the heart of the mountain, we have still more than $1\frac{1}{4}$ miles of solid rock above us. Therefore, we may almost say that this vast tunnel runs *under* the Alps. It could have been made much nearer the top of the mountain, but that would have meant a very high climb for the trains before

reaching the tunnel. Therefore the tunnel has been made comparatively low down the mountainside. On the north or Swiss side the entrance is only 2249 feet above sea-level, and the entrance on the Italian side is only 2079 feet. The tunnel slowly rises till it reaches a height of 2310 feet. That is the highest point, and above that there lies a mass of mountain a mile and 575 feet high. The tunnel slopes slightly toward each end, so that any water which enters may run down the slopes and escape.

There never was such a story as that of the building of this tunnel. The engineers expected to find great heat—for the deeper we go in the earth the more the temperature rises. They expected to find a heat of about 100 degrees, but when they came to the worst part they met a heat of 132 degrees, while scalding water in enormous quantities flowed in upon them. There were rivers and lakes hidden in the mountains of which they had previously known nothing. There were soft parts too in the mountains, which they had not expected to find. For all ordinary work they were prepared.

The two ends of the tunnel—Brigue on the Italian side, and Iselle on the Swiss—became cities of industry. At each end a river was harnessed and made to supply power for driving the many kinds of machinery which were used. A new colony sprang into existence at each end of the tunnel, in which were comfortable homes for the workmen and their families, churches, hospitals and places of amusement.

And though these little towns were of wood, every place was lighted by electricity, made by the running of the harnessed rivers. No workmen ever performed their tasks with greater comfort while working deep in the earth. They had special clothes to work in, special provisions in the form of warm and cold shower-baths, and cooling chambers were furnished, to prevent their feeling the cold on coming out from the hot depths of the mountain into the chill atmosphere of the Alps. To guard against impure air, machinery was built which forced in enormous quantities of cold, pure air, and drew out the foul air. Few horses were allowed in the tunnel, because the vapors from their bodies made the air impure; and special watering machinery instantly converted the dust of the tunnel into mud, so that the men should not breathe it. The conditions for the men were really excellent, and the men deserved it, for they worked with extraordinary good will under conditions which might have been truly terrible.

Work was begun at both ends of the tunnel at once—with 6000 men on the Italian side, where

the harder work was expected, and 4000 men on the Swiss side. Drills driven by hydraulic power were used to bore holes in the rock, and in the holes thus made charges of dynamite were placed and fired. Guns which were fired by water under heavy pressure smashed up the rock which the dynamite dislodged, and long trains carried away the rubbish and brought in building material, so that solid masonry could be built up to form walls, and to give extra support in place of the rock cut out. Day and night men were at work, working in shifts of eight hours each. All the machinery for the work had to be specially made, and with this the men bored away 18 feet of gallery a day; the men on the Italian side working toward the Swiss side, and those on the Swiss side boring in the direction of the Italian, so that when each side had done its work they might meet in the center of the tunnel.

For a time all went well. Soon, however, those on the Italian side met with unlooked-for difficulties. They broke into very soft and treacherous ground, where they had expected to meet solid rock. To make this secure, they erected enormous timbers, but these were crushed to atoms. Next, heavy steel girders were tried, but so great was the pressure of the moving masses above and all around that these became twisted like wires. Not until quick-drying concrete was built round them could the girders be made to hold up.

Then the workmen came upon an underground river of intensely cold water. It rushed into the galleries at the rate of 12,500 gallons a minute. That gives us 80,000 tons of water in the course of the day and night, enough to supply all the wants of a city of 900,000 people, or nearly Baltimore and Buffalo combined.

The poor men worked in mackintoshes and waterproof boots and leggings, but they were in a shower-bath the whole time, and up to their knees in water, and often in danger of drowning. Next, drainage systems had to be invented—pipes and deep channels in the rock—to carry away this dreadful river, and, after a delay of six months, the danger-spot was safely passed.

Very soon afterward, however, the rocks into which they were boring began to get hot and hotter, and streams of scalding water gushed out. Having passed a river of cold water, they had now come upon another, which filtered down through the scorching rocks, bringing their heat with it. It flowed into the galleries at the rate of nearly 250,000 gallons an hour—a river of scalding water. Again fresh machinery had to be thought out. Nobody on the spot dreamed of giving up the work, though everybody outside

thought that the task must be abandoned. The men on the Swiss side also had come upon baking rocks and scalding water. The same idea was adopted for both sides of the tunnel. On the Swiss side enormously powerful pumping machinery was put up, which pumped in cold water from beyond the end of the tunnel. This was pumped upon the burning rocks and upon the cracks from which the scalding water issued, and so cooled both rock and water. Cold water was also sprayed in the air to make it possible for the men to breathe.

The plan on the Swiss side worked well, until a great storm at that end of the tunnel caused a landslide, which cut off the water supply that had driven the pumping machinery. The hot water was still pouring in, so the engineers had to put up enormously strong iron doors, right across the tunnel where the boring machinery was placed. This, to a great extent, shut out the flow of hot water, and enabled the men to go on building up the walls in the rest of the tunnel. And there they had to leave their boring, and wait for the men on the Italian side to work their way through to them.

The brave fellows on the Italian side worked doggedly on. They now turned one river against another. The cold river through which they had fought their way was made to serve the pumps, and to help to cool the scorching rocks and water where their present work lay.

Little by little they worked their way onward to the spot where they expected to break through and find their friends on the Swiss side. They knew exactly the spot at which they *should* break through and make the tunnel complete. They had been for years working in what they hoped was a straight line. Had they gone quite straight, or had they gone astray? Might they have to go on boring, having found that they had missed the line after all? There was great excitement on both sides.

At last the men in the Swiss half heard the sound of the drills, and knew that their friends were approaching them. Twenty feet, nineteen feet, then only sixteen feet remained, and so the last barrier was gradually bitten away by the untiring drills. Then came the last charge of dynamite which was to open the way. It was put in and fired, and a hole in the rock eight feet wide opened. To the joy of everybody, they saw that the tunnel was complete! After twelve miles of boring, starting from different countries, the workmen met in the heart of the Alps with only the breadth of a hand between the points of their axes.

In May, 1906, the King of Italy and the President of Switzerland met in the tunnel, and a month later, nearly eight years from the beginning of the work, trains were running through the Simplon, the longest and deepest of all the tunnels in the world.

THE WONDERS OF THE TELEGRAPH

THE communicating or transmission of language to a distance is of very remote origin. The word "telegraphy," strictly defined, means "writing afar off." As practised to-day, however, it has a broader meaning, signifying the sending of messages to a distance by any means excepting speech.

The method of transmitting messages by sight signals is perhaps one of the earliest known. The sending up of columns of smoke from the top of high hills and mountains was one method used by the Indians of this country for many years; and flag and torch signaling, or "wig-wagging," as it is called, is still used by the army and navy to a certain extent.

Signaling by sound, such as blowing a whistle and ringing of bells, is used generally throughout the world; while the electric telegraph, an invention of comparatively recent years, is the most important and most used of all. An interesting and instructive article could be written upon

each of these different methods. But in the present article we shall confine ourselves to the electrical method.

Various methods of electric signaling were used to a limited extent up to the time of the wonderful invention of Samuel F. B. Morse and the practical working of his system which has resulted in our modern telegraph. A good deal of credit was due to Joseph Henry, a Princeton College professor, who, as the inventor of the electromagnet in a useful form, made the invention of Professor Morse possible and practical.

Nobody can say what electricity really is. It is not matter. It cannot be seen, though its effects are visible; it cannot be smelled or tasted. We call it a fluid because we cannot give it a better name. But though we do not know what it is, we know how to bring it into use, how to create or excite it, how to harness it, and make it our most marvelous and obedient servant; and one of the chief wonders electricity performs for

us takes place after we hand a telegram across the counter of a telegraph office. A telegram is one of the familiar things in our lives which are really so wonderful that no man can quite understand them.

To-day if we wish to send a telegram, say from New York to Charleston, we must have in the telegraph office a battery or dynamo from which we can send electricity along wires. If the wires coil round a piece of iron, then so long as the current of electricity is passing through the coil the iron acts as a magnet—an electromagnet, as it is called—and draws to it another piece of iron or a piece of steel. The moment the current ceases, the iron is no longer a magnet. When we send the electricity through this coil, we call it magnetizing the coil. The current flies swiftly along the wire, and while it is going the circuit is said to be closed. When the current ceases, the circuit is broken. Now, we will say, we are in New York, and we hand a telegram for Charleston to the telegraph operator.

Before him is a little lever of shining brass with a black rubber knob at the end. This lever is called a key. While that key is at rest, the circuit is broken. The moment the operator presses it down, the circuit is closed, and the current races along the telegraph wire. He taps away at his key, and the message flies over the wire, to be written down at the Charleston telegraph office. How is it done? Charleston is the receiving end. Well, there, at the end of the wire, they have an electromagnet made as we have seen, of wire and iron. A current comes from New York. It enters the office by the wire. It passes through the coil and makes the iron magnetic. The magnet attracts toward itself a little metal bar working on a lever, and every time this bar comes down toward the magnet the end of it taps upon a small screw; then when it goes up again it taps on another screw. Each tap that it makes corresponds with something that the operator in New York has done at his end of the wire.

The New York operator, as we have seen, presses down a key. That key, when at rest, has its knob raised in the air. There is a wire attached to the key. Now, when the key is pressed down, its under side touches another wire. The pressing down of the key joins these two wires together. That closes the circuit. The joining of the two wires instantly causes a current of electricity to flow from New York over the wire to Charleston. The instant that the key is allowed to rise from the wire underneath it, the current is stopped and the circuit is broken.

While the current is flowing, the coil and iron at Charleston become a magnet, which draws toward itself the small metal bar.

Clever men thought out a way of making this of use. They arranged that certain signals made with the sending key should stand for certain letters, just as certain motions of a flag, or staff, or other signal visible at a distance meant some definite message arranged between the sender and the receiver. We have only to agree once for all that a certain sign shall stand for a certain thing, and then we know what it means. And that is how we got the telegraph's A, B, C. A very short pressure of the key in New York gives two taps at Charleston, one very quickly after the other, and a longer pressure gives two taps, but with a longer interval between them. These double tappings, one with a short interval between the taps, and the other with a longer pause, correspond with the dots and dashes of the Morse alphabet. This alphabet is now universal. There are a few differences between that used in America and that employed in Europe and in cable-working, but in the main one alphabet of dots and dashes serves the entire world.

These dots and dashes of the telegraph signals take their names from the first apparatus used by Professor Morse. He did not realize that the operator could read the signal and messages by ear, paying attention to the interval between the clicks. He accordingly arranged that his receiver, or the electromagnet at the distant station, should be able to record the signals visibly and permanently. This he did by attaching to the movable piece of soft iron that was attracted by the electromagnet a point or pen, so that when it was pulled down it would come in contact with a moving paper tape and pierce or mark it. If the soft iron, the armature, it is called, was held down but for a moment (a short signal), the mark was a point or prick, and was called a "dot"; when the key was closed for a longer time the mark was a "dash." But as telegraph instruments were developed, and operators became skilful, it was found that the sound was sufficient, and instead of the Morse register, after 1855 to 1860 various types of sounders were used to the virtual exclusion of recording instruments on most large systems in America.

Now we have spoken of sending a message from New York to Charleston as if this were a simple matter of a single circuit. This served to explain the principle, and in fact would be the case over a short line. If two school-boys in the same town connected their houses by telegraph, they would require only a simple circuit

of sounders, keys, batteries, and wires. But for a long distance it is necessary to have one or more relays where a sounder not only gives out the click for the ear, but sends its message along on the next stage. The relay is much more sensitive than the sounder, so it works a local circuit in which a loud sounder is placed with a battery of its own, and the feeble current in dots and dashes can be read by an operator in the usual way.

We have seen that when we send our telegram from New York to Charleston the telegraph operator turns the letters which we have written on the printed blank into telegraphic letters by tapping at his key the signals according to the Morse code or alphabet. Each tap is registered at Charleston instantly it is made. With each pressure upon the key the circuit is closed and the current passes for a certain length of time, conveying a sign that means part of a letter. Each time the key is placed at rest in its ordinary position, the current ceases to flow.

But there is a limit to the speed at which a man can tap his key. If he is very skilful and quick he may be able to send as many as forty words a minute. More likely he will not be able to send more than twenty-five. That is not quick enough when the message he sends, instead of being a little telegram from one of ourselves, is a despatch of thousands of words, as a speech or an account of some event for the newspaper. For this, another system is used. A message of 1200 words, for instance, would be divided, say among ten operators, each of whom sits before a machine that punches holes in a ribbon of paper, the holes corresponding to the letters of the Morse alphabet. Each clerk punches 120 words of the message at the rate of 25 words a minute, so that, when the work is divided in this way, the whole message is punched out on the tape, or ribbon, in about five minutes. The ribbon is then run through an elaborate telegraph instrument, called an automatic transmitter because it works itself. The ribbon runs through in such a manner that the circuit is closed at each hole in the paper representing a dot or a dash, and the current flows along the line, to be registered at the other end, in ink, upon a tape. By this machine, messages can be sent at the rate of 400 words a minute. The recording of the dots and dashes upon a tape at the receiving end is necessary, because no one could write out the message at the rapid rate at which it is received. The writing out is done from the printed dots and dashes on the receiving tape.

Perhaps the greatest wonder of the telegraph line is the fact that several messages can be sent

at the same time. Thus we have duplex and quadruplex working. Two messages can be traveling over one wire at the same time from New York to Charleston, while two others are coming at the same time over the same wire from Charleston to New York. This is done by arranging different strengths of current. The messages that are traveling together from the north to the south are each sent by a current of different strength from that of the others, and the same is the case with those coming from the south. Each current goes to a receiver that takes a current of particular strength. If we have relatives away over the sea to whom we may wish to telegraph, we can reach them with a message carried by electricity under the sea. Cables, in which is used, not the bare galvanized iron wire we see on telegraph poles, but a copper conductor protected first by an insulation of gutta-percha or rubber, and then by a strong sheathing of steel wires, run under the Atlantic and Pacific oceans, under the Mediterranean Sea, the Black Sea, the Indian Ocean, the North Sea, the English Channel, and other bodies of water. There are about 250,000 miles of these submarine cables in use, so that we can exchange messages with Europe, Australia, New Zealand, India, China, and all civilized countries. The principle is the same as in the land telegraph, but the wires are different, and the rate of telegraphing is slower, as the current passing through these long wires is necessarily weaker, which makes the recording of the messages received a slower operation.

In fact, we do not have the loud clicking sounder nor the punctured tape. We have an instrument that can detect the feeblest currents, and this is a modification of the galvanometer, where a little magnet is suspended within a coil through which the current flows. If the current passes in one direction, the needle swings to the right; if it is going in the opposite direction, to the left. Once it was necessary to put a small mirror in the needle and watch the movement of a reflected spot of light. Now we have a siphon recorder where the needle carries a little pen filled with ink, which traces a wavy line on a paper tape. If there is an upward jog in the line, that means a dot; if it is down, it is a dash, and the message can be read just as easily as if it were picked out. The cable-key is different from that of the land telegraph, for, as we have seen, the operator not only breaks the current but changes its direction, so that the signals are more pronounced.

If the ordinary bare telegraph wires seen on the poles were used, the current would run off

into the sea and be lost; so the wires have to be encased in gutta-percha, and bound round with tape, and yarn, and brass, and tarred hemp, and over all are wound coils of stout wire, to protect the cable from the sea and from the rocks at the bottom of the ocean. For long distances, only one wire is placed inside the cable, but for shorter distances many can be used, as is done in a telephone cable. More than one message can be sent over the cable at the same time.

The speed at which cablegrams can travel is very great, though we have not yet the instruments to receive the messages quickly. A signal has been sent 8000 miles under water in a single second. So quickly does the flash travel that we can use a signal to determine exact time at distant places and compare the standard clocks of two astronomical observatories far separated. But we could not send a long message at this rate. It is costly to cable across the Atlantic, for not only is the cable itself expensive to make, lay, and maintain, but it can only do a certain amount of business in a year. On account of this expense codes are used by which one word may stand for a dozen or more words. By this means, time and money are saved. Once an English firm cabled from London to their manager in Victoria, British Columbia, and received the answer in a minute and a half, the distance traveled by message and reply together being 18,000 miles.

At an electrical exhibition in Chicago, a message was sent from a room there through the United States to Canada, from Canada to London, from London to Portugal, Spain, Egypt, India, and Japan. It came back by the same route, and was received in the same room from which it had started, but at another instrument. It had been round the world in fifty minutes. This speed of cable-signals has been strikingly illustrated on several occasions when the United States Naval Observatory at Washington on New Year's Eve or other special occasions has sent out a special series of midnight time-signals to mark the beginning of the new year. Telegraph and cable companies have united to send the tick of the standard clock at Washington, so that signals were received from points on the earth's surface as far distant as Greenwich in England and Adelaide in Australia, and from Sitka in far-away Alaska and Buenos Aires in South America. Messages east and west have met in Australia within a very few seconds, and the time of transmission to Sydney, New South Wales, was but $2\frac{1}{4}$ seconds.

It is apparent that our telegraph lines are not

used much during the night hours except for newspaper messages and those of immediate importance. Accordingly, the telegraph companies determined to make a special rate for night letters in which many more words could be transmitted for the same expense as a day message which was sent over the line and delivered immediately. These night letters make it practicable for full instructions or particulars to be given by business houses to their various representatives, and for relatives and friends to send each other messages with complete information about their health, plans, movements, etc. These telegraph letters soon began to be extensively used, and they were followed by cable letters for which a similar reduction in rate was made for messages that would undergo a reasonable delay in transmission, but would reach across the ocean in sufficient season over a night or a Sunday to give the receiver the desired information in full and free from misunderstanding that might result from an abbreviated or code message.

Undoubtedly the most wonderful method of telegraphing is that without wires. It was known for some years that electric waves are carried through the air in all directions, with the speed of light, and this knowledge has been turned to useful purposes.

By the use of an instrument called a transmitter, these electric waves can be sent bounding forth through the air in all directions. By making a receiver in tune with the transmitter, capable of responding to the same kind of waves, we can make that receiver take a message. The first instrument devised to receive these electric waves was called a coherer. A coherer is a glass tube, sealed at both ends with metal, and filled with metal filings. When an electric wave comes along, it passes through this tube. It magnetizes the metal filings, and causes them to draw close together—to cohere, and to close the circuit. The wave is quickly gone, the filings are no longer magnetized, and the circuit is then broken again.

The coherer receives a light tap from a little automatic tapper, and the filings fall apart again instantly, to be as they were before, ready to receive the next electric wave. When the metal filings come together and close the circuit, they operate a bell or sounder, like the simple instrument in the country telegraph office, and the message that they tick is read and written down, ready to be sent to the person for whom it is intended.

But the coherer is only one of a number of devices that can be used to detect the electrical

waves. It must be remembered that these waves strike suspended wires that are raised above the earth's surface, sometimes singly, sometimes in pairs, and sometimes in the form of a net. These wires are called antennæ, like the long feelers on the beetle's head. They are familiar sights in the rigging of a modern battle-ship, or large passenger vessel, for now seagoing steamers that carry passengers are required to be equipped with wireless telephone for safety in case of collision or other accident. The waves striking these antennæ set up electrical oscillations in the circuit which will affect the coherer as has been described.

There are also other forms of detectors, many of which are very complicated and are arranged so that the various signals, even from across the ocean, may be received. These detectors, when rapid electrical currents are produced in the receiving circuit by the electrical waves, may have the magnetism of metals used in their construction affected; or a fine wire may be heated; or certain chemical actions may be set up; the conductivity of very thin gases may be altered; or certain crystals that conduct electricity may have this power of conduction varied under the influence of the rapid oscillations of the current; or, finally, there may be a movable conductor, near a fixed conductor in which the oscillations are taking place, so excited that it enables the presence of the waves to be detected.

Instead of the Morse relay and register used with the coherer, it is now customary to employ a sensitive telephone receiver, and the operator in his deck-house on a large battle-ship, or steamer, sits with this receiver at his ear, listening for the waves that come across the ocean, fall on his wires suspended in the air, and produce the oscillations in his receiver that make a loud click in the telephone. These signals are sent in the ordinary Morse code, and will be received on any ship where the apparatus is tuned to the same wave-length. Many stations, both on board ship and on land, can be tuned to the number of wave-lengths, and thus they are independent of any special system.

An interesting incident occurred in 1912 when a portion of the Royal family, of Great Britain, returning from India on a large passenger steamer, were shipwrecked on the coast of North Africa. Their signals of distress were heard on several ships which came to their rescue, but not by the British naval vessels at Gibraltar, whose apparatus was tuned to one wave-length only, as used in the British naval service.

Thus we send a message thousands of miles across the ocean without the help of wires.

Here again the rate is slow. Cablegrams run off at the rate of fifty words a minute, but the wire-less telegrams go at the rate of only twenty-five words a minute. Some day, of course, this pace will be greatly improved. Wireless telegraphy is one of the great gifts that inventors have given to mankind, and we cannot yet realize the importance of it to the world. How wonderful is the power that wireless telegraphy gives us to speak across the sea! In 1909 happened a wonderful thing, showing how the power of telegraphy without wires may save great disasters at sea. Let us read the story of how a man tapping away into space saved a thousand lives.

Let us picture to ourselves an immense steamship moving slowly from its berth. The pier is crowded with people waving their hands and fluttering handkerchiefs. From the side of the ship, on all the decks, lean a multitude of passengers waving farewell. The space between these two crowds slowly widens. Between ship and shore flows an increasing space of troubled water. The faces of people become indistinct. The sounds die away. Then the engines get to work in earnest and the great ship moves forward and draws impressively to sea. The passengers hurry to their cabins. They see that everything is comfortable for them. They put on overcoats and wraps, and take to the decks. Before they begin to walk about, however, they think of their families ashore, their wives, husbands, children, sweethearts. They go to one of the rooms on the ship and write messages of affection and good cheer. They ring a bell. A steward comes, and the messages are handed to him. They are carried to the operator in charge of the wireless telegraph. The passengers begin to walk about the liner and to enjoy themselves.

In his little deck-cabin the operator of the wireless telegraph sits before his machine. On the table in front of him are the messages of passengers, a pile of crowded papers. It is the business of the operator to send those messages. He flips an A, B, C into the ether, and somehow or another those letters are received on shore. They travel without wings, without wires; they arrive.

A fog descends upon the sea; the engines are slowed; the fog-horn begins to sound.

Tap, tap, says the operator, earning his daily bread.

Crash!

A noise like thunder. A shock that sends everything flying. A tearing and rending and splintering of timbers. A dull, thudding crumple of steel plates. The roar of water rushing in. The staggering shudder of the whole ship.

Shrieks and cries of people from every quarter. Voices shouting through the fog—loud voices of command. And darkness. Every electric light goes out.

The operator interrupts a sweetheart's message, and taps out the letters C, Q, D, the danger-signal of the seas. Through the cries of the passengers, above the shouts of command, piercing the black fog that shrouds the ocean, those invisible letters strike on receivers ashore, and on numerous receivers aboard other ships, almost at the moment when the operator sets them free. They mean to those who receive them: "In serious trouble, need immediate help."

"What has happened? The steamer 'Florida' has rammed the great White Star liner 'Republic.'" The water pours in, life-boats are made ready, the panic-stricken passengers pray for delivery from death.

Through it all the operator sits amid the ruin of his office, tapping, tapping, tapping his messages into space.

On another vessel, in another little office, another operator sits tapping away at the ether. The telegraph operator on the "Baltic" is sending his passengers' messages home when his receiver records the distress-call from the "Republic." The sinking ship is sixty miles away, drifting in a dense fog, and the "Baltic" changes its course and sets out to find it. From half-past seven in the morning till half-past six at night the "Baltic" scours the sea, talking all day long to the ship that is near sinking with a thousand lives. All day long on the sinking ship sits the telegraph operator, tapping into space a signal of distress.

Let us try to imagine the scene. Two ships are in peril in a thick fog. Two thousand men, women, and children are in danger of death. In a little room on one of the vessels a man is tap-

ping at a keyboard, tapping into space a bitter cry for help. The air-waves, set in motion by his tapping, travel sixty miles and then they find, on another ship, a sympathetic disk, on which they register themselves; and below in the operator's room on that other ship the tapping is repeated, and the ship's distress made known.

Two other ships pick up the silent cry that trembles through the fog, and all day long three vessels seek the sinking ship, with which they keep in touch by constant tapping and by communication with telegraph stations on land. It is a thrilling thing to think of—these ships drifting in the fog, talking to each other over sixty miles of space, carrying along an invisible ocean new life for two thousand beating hearts. "We are sinking rapidly," says one message. "We can hear a bomb to the west of us; is it yours?" says another. The "Lucania" asks the "Baltic" to "listen for four blasts." Another ship asks the "Baltic" to "make as much noise as possible." The captain of the "Republic" thinks he hears a steamer's whistle, and appeals to the "Baltic" to make haste, for his ship is "sinking fast."

And then at last, after a whole day's search, steering and zigzagging for two hundred miles, the "Baltic" received the message from the sinking ship: "You are very close now; right abeam. Come carefully. You are on our port side. Have just seen your rocket. You are very close to us." They were within one hundred feet, and saw the faint glare of a green light, and in twelve hours the sinking ships were emptied of their living freight.

Only a few years ago the "Republic" would have been completely lost, and such a catastrophe was prevented, for the first time in the history of the world, by wireless telegraphy, a power that no man understands.



The Story of the Submarine.



BY WILLIAM O. STEVENS

THERE was a time when "Twenty Thousand Leagues under the Sea" was for me the finest story ever written; and when, some years afterward, I saw a picture of the Holland submarine, I was sure that the inventor had got the idea from Captain Nemo's "Nautilus." It is true that Mr. Lake, the inventor of the submarine that bears his name, was inspired to his life-work by reading Jules Verne's story at the age of ten; but the fact remains that the submarine idea was over two hundred years old when the clever French writer was born.

When President Roosevelt made a trip in a submarine at one time, there was a great stir in the newspapers; but not many people know that as long ago as 1620, King James the First made a journey of two or three hours below the surface of the Thames on board the first navigable submarine in history. This was the invention of a Dutch physician, Cornelius Van Drebel, a man in high favor with the king. It was built of wood, covered with greased leather to keep out the water, and propelled by twelve rowers, whose oar-holes, also, were protected against leaking by greased leather. Van Drebel boasted that he kept the air inside by means of a secret elixir, but after his death his enemies declared that he must have had air-pipes sticking out of the water. At any rate, he died with his secret while in the midst of his experiments.

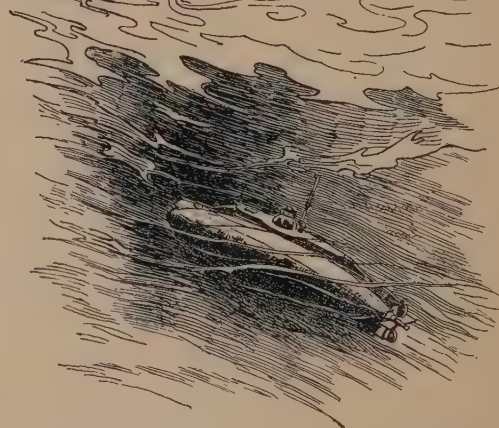
When we think of the difference in mechanical science between then and now, perhaps the king who would risk his life in such a boat was not so much of a coward after all!

During the next one hundred and fifty years,

several inventors tried to build submarines. One of them, oddly enough, was a John Holland, who took out a patent for his submarine in 1691. In 1891, just two hundred years later, another John Holland was perfecting a submarine which has come to be the accepted type in our Navy.

But the glory of making the first submarine that actually operated in time of war belongs to an American, David Bushnell, who built the "Turtle" to destroy the British blockading ships in New York Harbor.

When the "Turtle" was finished, she was manned by a sergeant of the Continental army who had been carefully trained in the use of the boat by Bushnell himself. One night the little submarine was towed near a huge man-o'-war, when it submerged and came up under the ship's bottom. But the sergeant found that, try as he might, he could not bore through the copper sheathing. Soon he found himself being carried away by the



tide, and, as day was breaking, he cast loose his mine and paddled for shore. The mine was set by clockwork and, after bobbing about on the surface awhile, it suddenly went off with a tremendous explosion, which did no damage. The attempt had failed, but it showed that submarine warfare was possible.

The chief objection seemed to be, and continued to be for nearly a century, that submarine warfare was "dastardly." The English were indignant at what they called "villainous and underhanded" methods, and Bushnell found that the American authorities felt the same way; so all he got for his trouble was hard names from friend and foe.

The next submarine builder of note was also an American—and a famous one—Robert Fulton. His boat was the "Nautilus" (from which Jules Verne took the name for Captain Nemo's ship), propelled, like the "Turtle," by hand, only instead of oars there was a wheel astern. She had also a sail for use when on the surface. Notice the first appearance of the "cigar shape," which set the fashion for all the submarines that have followed.

As Fulton was in France at the time he was building the boat, he tried to get the French government interested. Finally, in 1801, he was allowed to give his boat a public trial in the harbor

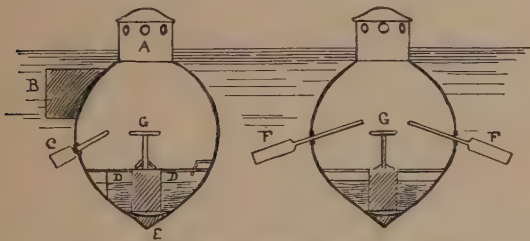


DIAGRAM OF THE SUBMARINE "TURTLE."

of Brest. There he made three trips without a hitch; in the last one he stayed under water five hours at a stretch, and blew up an old hulk with his mine. The crowds cheered, and the officials smiled; then, after pondering awhile, they told him politely that the "Nautilus" would n't do. It was much too novel for old frigate captains to encourage.

Disheartened by this, Fulton went to England, where he gave another successful performance in the Thames by blowing up an old Danish frigate. Again, his very success was against him. The Admiralty solemnly declared that the "Nautilus" was a device that threatened navies; and, since England's mainstay was her navy, she must not encourage such a thing! Poor Fulton came back to America, and even here he met

nothing but opposition to his "villainous" idea. In despair, he gave himself up to the development of the steamboat.

Another American, with a more romantic turn of mind, began in 1821 to build an enormous sub-

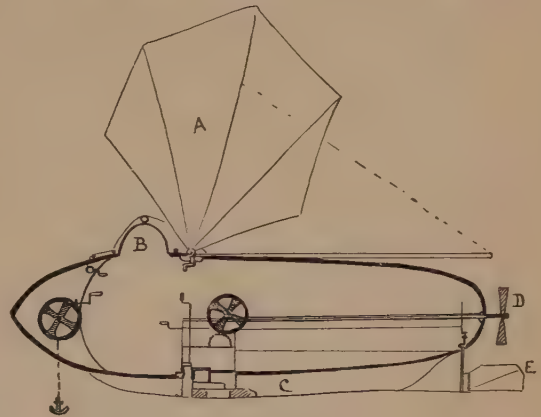


DIAGRAM OF THE SUBMARINE "NAUTILUS."

marine, with which he was going to St. Helena to rescue Napoleon! Unfortunately, Napoleon died before the boat was finished. But throughout the first half of the century, men of all nations, especially the French, were puzzling over submarine construction. Bauer, a German, had an experience even more discouraging than Fulton's. Failing, after endless trouble, in Germany, Austria, and England, he succeeded only long enough in Russia to prove that he could make his boat work under water, when there, too, he was driven by official greed and jealousy out of the country.

After Fulton's demonstrations, the greatest advance in submarine construction was made by the Confederates in our Civil War. They combined the uses of steam and electricity, and carried the "spar" torpedo in the bow. But the only one of their submarines that succeeded in destroying an enemy was as simple as the "Nautilus." This "David," as submarines were then called, was about sixty feet long and manned by nine men, eight of whom worked the screw-shaft by hand, while the ninth acted as pilot. On the night of February 17, 1864, this little craft went out to attack the "Housatonic," a Federal ship anchored in Charleston Harbor. The officer of the deck saw something rippling along the surface of the water directly toward the ship, and instantly gave the alarm; but, before the "Housatonic" could move out of the way, the "David" was alongside, and, a minute after, one hundred pounds of powder exploded under the keel of the ship. She fairly jumped out of the water and then lurched heavily to the bottom. During the

confusion of rescuing the survivors, the "David" apparently escaped, for she could not be found.

This exploit was the first case of a submarine destroying an enemy, and the only case in the Civil War. The boat, before this, had had a tragic history. Five times before she had gone to the bottom with her crews, and five times she had been raised and remanned by men who volunteered for the perilous duty. Thirty-five men had already been lost in her when she sallied out to attack the "Housatonic." Then, after the war, when divers went down to the wrecked ship, they found the "David" wedged into the very hole she had made, evidently sucked in by the rush of water.

The effect of the "David's" torpedo proved that the submarine was worthy of respect, and

thereafter there was no more talk about its being "infamous." From the Civil War to our day there has been scarcely a year when an inventor in some part of the world has not taken out a submarine patent.

The result is that the modern submarine is a maze of machinery, with scarcely a square inch of room on the side to spare.

While we wonder at this perfection of the submarine of to-day, we should remember that it is the result of the labor of hundreds of inventors and hundreds of years, with the sacrifice of many lives.

The submarine may not yet be adapted for pleasure cruises like that of Captain Nemo's "Nautilus," but it has at last fought its way to a position among the world's vessels of war.

THE UNDER-SEAS SAILOR AND HIS BOAT

HOW IT FEELS TO GO DOWN IN A SUBMARINE

BY A. W. ROLKER

TEN men sealed inside a gigantic torpedo, now skimming amid sunshine over the glassy surface of a summer sea, now vanishing and diving two hundred feet into the blackness toward an ocean bottom, seeing nothing save a maze of whirling brass and glittering steel, hearing nothing save the deafening drone of hammering, thumping, pounding engines, and all the time tense with the realization that death in one of its most harrowing forms may confront them at any instant—these are some of the experiences of the men detailed to the submarine torpedo-boat service of our Navy. Indeed, the submarine torpedo-boat man combines the hazards of the diver and the "sand-hog"—as the under-river tunneler is called—and takes those of a man-of-war's man and a sailor into the bargain.

Even in time of peace the submariner's life is threatened. For, in order to keep men toned up to the highest degree of war efficiency, the vessels are ordered out for practice frequently, and, wonderful though the vessel is in its possibilities for demolishing enemies, only to an extent can the men inside control what is going to happen to themselves.

Without even a chance of knowing it, the submarine may rise and come to the surface directly in front of the prow of a steamship only to be cut in two like an egg-shell. Often diving farther than the keels of the deepest ocean vessels reach, the submarine is in a strange maritime

world where it must take chances in running upon uncharted reefs, or striking water-logged spars or spiles that may meet it head on and lance a hole through the thin plates and hold the boat captive on an ocean bottom. Again, in the frail vessel subjected to an enormous strain while submerged, structural weakness may develop, and the hull may spring a serious leak; or, through negligence, the water-tight cover over the hatch may be improperly screwed down while the crew gazes on, horror-stricken and powerless. And as if these risks were not enough, the men are caged up as if inside the crater of a threatening volcano, for each submarine carries four monstrous torpedoes more than sixteen feet long, each loaded with 190 pounds of guncotton, enough to blow a "Dreadnought" out of water. To these dangers add the fact that when a submarine torpedo-boat sends its deadly sting into an enemy there is the possibility that not a man aboard the boat would live to tell the tale, and you have a fair idea what it means to be a submarine torpedo-boat man.

DESCRIPTION OF A SUBMARINE

No matter how much you may have screwed up your courage, when the time comes to make up your mind to board a submarine boat and take chances, your imagination is apt to run riot. Looking down from the pier from which you

are to embark you see a lead-gray curved surface of steel, which rises above the water like the back of a big whale with a cheese-box hump and a hatch and a pair of ship's ventilators about the middle of it, and a mast at either end. What strikes you most is the insignificant size of the bleak, grim contrivance to which you are supposed to trust your life. All you see is a flat deck-space, twenty-five or thirty feet long, three feet wide at the middle, and tapering to a point at either end, the level of the deck being an absurd twenty-four or thirty inches above the water surface.

As a matter of fact, what you are looking at is the back of a perfectly steerable, mechanical fish, one hundred feet long, and eleven feet at its greatest diameter, built of half-inch-thick steel plates, and provided at the stern not only with the usual vertical rudder with which all boats are steered in a horizontal plane, but also with a horizontal or "diving rudder" by means of which she is made to steer up or down. The tail with which this under-water colossus sends its hull of 170 tons' displacement through the water, consists of twin propeller screws, each driven by a separate high-power internal combustion engine while the vessel runs afloat or awash, and each driven by a separate electric motor while the boat runs submerged. If the captain wishes, he can take you on one continuous run of eight hundred miles, running either on the surface or awash, with his gasoline engines at a speed of thirteen miles an hour; and then he might dive, using his electric motor and storage batteries, and make one long "fetch" of fifty miles, at a rate of nine miles an hour, before his supply of electricity would be exhausted. At the end of these eight hundred and fifty miles he would have to make port for gasoline, would simply reverse his electric motor and run them as dynamos by means of his ship's engines until the batteries were recharged, rendering his boats as efficient as in the first place. No toy, therefore, is this submarine, but a formidable fighting craft, important enough to have induced Congress to appropriate millions to build other submarines like her to be added to the number already on the list of the Navy.

THE IDEAL SUBMARINE MAN

BUT, gazing down upon the back of this uncanny vessel, which is in reality nothing but an enormous steerable torpedo with a human crew, what interests you most just now are the men who handle the boat and into whose hands you are to intrust your life.

Lounging upon the end of the pier or on the deck of the submarine, the crew little resembles the sort of semi-herces you might picture as belonging to this service. As likely as not, you are apt to meet a crew not a single one of whom is wearing what even remotely suggests a naval uniform. As a general rule the "captain" wears a uniform, one that is old and weather-beaten, with braid and buttons tarnished by the spray and spume of much salt water. Possibly the ensign or the junior lieutenant, the second in command, is similarly attired. But the three engineers, the two electricians, the gunner and his assistant, and the able-bodied seamen, these are apt to be togged out in "any old thing," from cardigan jackets and civilians' trousers frayed at the ends, down to undershirts and tattered overalls; for the Department recognizes that the submarine service is hard on uniforms, and it is lenient in this respect.

But though the men may appear at first sight disreputable, as a matter of fact you are gazing at one of the most marvelously drilled and, disciplined crews of human beings—high-class, picked men, not one of whom has been tried and found wanting. Indeed, the submarine itself sifts the wheat from the chaff. A nervous man, or a man otherwise unsuited by temperament to the work, would wear himself out to a nervous wreck inside of a month, simply by his own imagination. The crew is made up of *young* men, with alert, intelligent, manly faces, young men lured by the very dangers of the work, by the distinction of belonging to that branch of the Navy which is most perilous, by the chances of doing great big things if opportunity only will offer, and by the love of strong natures for excitement and adventure.

ON THE DECK OF A SUBMARINE

STEPPING upon the deck of a submarine you are startled to see how desperately near your feet are to the water. Of course, you have expected something like this at first glance at the boat, but as you actually stand upon the deck, the greatest width of which you could cover at a single stride, and as you gaze at the wavelets leaping up within a foot of your toes, there is a nervous cribbling about the ankles, and you wonder whether you will be seized with giddiness and become unable to resist the temptation of leaping overboard once the boat gets under way. You wish there were a rail around the deck or even a bare inch-high cleat to prevent you from slipping into the water; for there is nothing but the two frail ten-foot masts, and they are where

the deck ceases, being only for the peaceful purpose of showing observers on shore the location of the boat when partly submerged.

Out of the middle of the deck arises the conning-tower, which is the captain's bridge while the vessel runs afloat, and out of which the captain can peer in all directions when the boat runs awash; and telescoped in front of the tower is the eye of the submarine, the periscope. One glance at the conning-tower upsets all your notions of what this contrivance must be like. In shape it resembles a thirty-six-inch-long piece of twenty-inch sewer-pipe, provided with a flat, hinged lid and with a circle of narrow slit windows, two inches wide and three times as long. The lid being open to permit ventilation inside the hull, you can gage the inside diameter of the tower as a trifle less than that of a sidewalk coal-hole, and you wonder how in the world you are going to squeeze through to get into the boat. Really, however, you are not supposed to squeeze through. The inside of the tower is lined with a maze of speaking-tubes and electric wires and compasses and bell-pulls and valves and wheels, the nerves leading from the captain's palm throughout the ship, and these might be injured were the tower ordinarily used as a companion-way. Generally, the captain glides in and out of this hole; but the crew descends by way of the hatch.

UNDER WAY

WHEN a submarine gets under way she leaves without fuss or feathers, without any of the ceremonies accompanying events on other war-ships. The submarine lives in the dark, striking without an instant's warning like an adder; and direct and to the point is everything that happens aboard the grim fighter.

Long before you have appeared, the vessel has been tested, as she is tested every day whether slated for a run or otherwise. The engines and the dynamos have been turned over and over, the storage batteries have been tested, each valve, each tube, each wire, each bolt and rivet and wing nut has been inspected as if life itself depended upon it. When the vessel is ready to start, the men simply disappear below, the captain takes his seat on the conning-tower, gives word to cast off and "yanks" the bell-pull leading to the engine-room. Simultaneously you feel a tremor throughout the vessel, a deep bass rumble comes out of the open hatch, and like a thing alive the boat moves forward.

Faster and faster revolve the engines, the rumbling settling into the run of a song, farther and farther and faster and faster moves the

craft toward broad water until she is darting forward full speed ahead.

For the first time in your life you get an idea of what a fabulous rate of speed thirteen knots an hour is when viewed from the flat side of a plank with a river licking your boot tops. Twenty knots on the deck of a torpedo-boat destroyer may have failed to impress you, but sledding over the surface of the water on the narrow deck of one of these submarines amply provides for your desire for sensations. Back, back whisks the green water on each side of you as if you were gazing over the stern of a fast moving motor-boat. But there is no suggestion of dizziness, no feeling as if you might be tempted to leap overboard, as might come to you when gazing down a precipice. There is nothing of this save the sane fear that possibly you might misstep and fall overboard to disappear in the trail of the white froth boiling behind in a long, narrow streak. All else is exhilaration and healthful excitement. The wind whistles in your ears and blows against your face and through your hair and into your eyes until you must squint them.

Should the water be rough, or should white-caps rise, the bow wave over the forward deck climbs higher and higher, fetching up against the conning-tower, smashing into mist and rainbows and dousing you with cool, salt spume and spray. Your one fear is: what would happen were a whitecap larger than the rest to board the deck and drop into the hatch? But this is the captain's affair and he, wheel in hand and calmly alert, sits on the edge of the tower as if carved of stone. Mile after mile he sits gazing into the distance, now and then giving his wheel a spoke or two, the vessel, steady as a church, answering the helm and taking seas as if she were a delicately balanced steam-yacht rather than a devil-fish among the fighters of the Navy.

Running in this wise the submarine might cover her eight hundred miles at one stretch, if seas permit, gunner, assistant gunner, and others of the crew not on duty standing upon deck if they wish, while through ventilators and down through the conning-tower waft drafts of moist, cool sea-air.

Should seas arise and threaten to wash into the hatch the captain simply orders the crew below and the hatch sealed. If he does not mind a bucket of water down the back of his neck, he may stay where he is for a time until the seas become even more unruly, when he may glide down the tower, either leaving the lid open to peer over the edge like a jack-in-the-box, or sealing the lid after him and peering through the

slot-holes—depending upon the roughness of the water.

In case seas continue rising and run so high as to threaten to carry away the ventilators, these are telescoped into the hull and the openings through the deck sealed, when you find yourself safe as if inside a gigantic stoppered bottle tossing on the bosom of the seas, now scaling skyward as if shot out of a rocket, and now tobogganing down mountain sides of water. No gale, scattering wreckage and death on high seas, no hurricane, razing coast cities, can affect this craft so long as there is sea room, any more than seas could wreck a feather; and, barring a severe dose of seasickness that would come to you, you would sit as comfortably as in the smoking-room of your pet liner, the only sounds of the fury without being the swish and wash as seas wash clear over you.

INSIDE A SUBMARINE

CLIMBING down ten rungs of an iron ladder into the interior of a submarine is like going into a boiler-shop where there is one continuous, deafening, ear-splitting racket, like a dozen trip-hammers clattering a tattoo amid a grind and rumble and thump of machinery as if especially designed to burst your ear-drums. At first the noise in that narrowly confined space is painful and bewildering. To make yourself at all heard you must shout into the ear of a companion. So intense is the strain that you marvel how day in and day out human ears can withstand the ordeal.

You find yourself inside what seems an enormous steel cigar, painted a neat pearl-gray, a color which is serviceable and does not dazzle the eye. Light comes to you partly through portholes and in part from incandescent lamps placed fore and aft in the darker parts of the hull. You have expected, of course, to land in a tangle of whirling machinery that fills the inside of the boat from stem to stern, threatening with every revolution to take an arm or a leg off. Instead, the first thing you see is an uninterrupted "working space" or deck, measuring seven feet by twenty-five or thirty feet. At the stern, far in the background, are the machines and engines; in fact, this section of the vessel is nothing but machinery, a rumbling mass of silvery steel and glittering brass revolving at the rate of five hundred times a minute, so compact that you wonder how the various parts can turn without conflicting, or how it is possible for human hands to squeeze through the maze to oil the machinery.

But this economy of space is as nothing to what you will see. The floor you stand on is a

cover for the cells of the storage batteries wherein is pent up the electricity with which your boat will propel herself when she runs submerged. The walls amidships and the space in the bow are gigantic ballast tanks to be filled with water that will play a part shortly when you get ready to dive. The four torpedoes, measuring sixteen feet three inches long, eighteen inches in diameter, and weighing fifteen hundred pounds each, are lashed end for end in pairs at either side, and directly over these are tool-boxes, and hinged bunks for the crew to sleep in. The very air which is taken along to keep life in you in case the boat should be detained beneath the surface longer than usual, is compressed in a steel cylinder to two thousand pounds per square inch—a pressure so intense that were the cylinder to spring a leak no larger than a pin-hole, and were the tiny stream of escaping air to strike a human being, it would penetrate him through and through and drill a hole through an inch-thick board behind him.

And yet everything about the interior arrangements of this boat is so simple that you can see at a glance its purpose. Away forward, where the tip of the cigar comes to a point, are the two torpedo tubes out of which the gunner will send his deadly projectiles seething beneath the waters at the rate of thirty-five knots an hour against an unsuspecting hull. Directly under the conning-tower is a platform three feet square and elevated three feet from the deck, upon which the captain stands, head and shoulders extending into the tower so that while at his post he is visible to the crew only from the waist line down; and at the feet of the captain, and on a level with his platform, is the station of the second in command, in charge of the wheel that controls the diving rudders and the gages that register the angle of ascent and decline, and show how deep the boat is down. The two officers are in personal communication so that in case of heart-disease or other mishap either can jump to the other man's place.

"DIVE!"

THE order to dive is the peal of an electric gong that clamors high above the racket of the engines, and is most likely to come when you least expect it and while the boat is proceeding on the surface, hatches, ventilators, and conning-tower wide open. Within two and one half minutes of the sounding of that signal, the boat is supposed to have vanished utterly from the surface; and what takes place within that time happens too quickly to be noticed. With the first stroke of the alarm the air is as if surcharged



A SUBMARINE ON THE SURFACE, AT CRUISING SPEED.

with electricity. Men are everywhere, each running to his post. The engines cease to revolve. The engineers sever the couplings between the engines and the shafts and connect the shafts with the electric motors. The electricians are at their switchboards awaiting only the word to turn on the current. The gunner, the assistant gunner, and the able-bodied seamen screw down hatches and take in the ventilators. The junior officer, diving-wheel in hand, turns on the valves which admit floods of water into the ballast tanks.

You hear the water as it gurgles and seethes into the tanks, and you hear the displaced air whistling out of the valves on top. You feel the decks settle under you and realize you are going down, just as you would feel this in an elevator cage lowered gradually. As

the sinking proceeds, if you look at the portholes, you can see as the level of the water reaches the glass and rises and rises until instead of daylight there is a green-gray mist and you



THE SUBMARINE OCTOPUS, DIVING.

continue to sink until, the ballast tanks having been filled, only two inches of the deck are above the water's surface—the submarine is awash.

Briefly, what the men have done is to destroy the buoyancy of the boat by admitting water, so gaging the cubical contents of the ballast tanks that the vessel is balanced so delicately that of herself she will come to the surface showing only two inches above water, while all that is necessary to send her under to any desired depth within the fraction of an inch is the mere declining of the horizontal rudder at the stern. In fact, your vessel is so balanced on a hair-trigger edge that the weight of four 200-pound men would send her under, and so delicately balanced that were it possible to look through the bottom of the boat into the depths beneath, its keel might be brought against the glass of an open-face watch in place without breaking the crystal.

As the electric motors begin to buzz and hum, sending tremors throughout the boat and forcing her ahead, there is no sensation of motion. The vessel might be standing still or might be moving backward for aught you can tell. You have lost your ability to discern either speed or direction, for there are no stationary objects by which you can gage position. As the diving rudder is

Smoothly and evenly, as if you were gliding down a hill in a trolley-car, you feel your boat tobogganing into the depths. You hear the water as it breaks against the conning-tower, hear the swish and wash of the waves as they climb on deck, and hear the seething as they angrily close over you. The boat might glide into the depths decorously at an angle of four or five degrees; or she might seem to kick up her stern and lower her nose threatening to turn a somersault and dive at an angle of twenty degrees, but the sensation would be no more disagreeable than coasting. All you see is that the deck is correspondingly declined. This, and the fact that the gray-green against the port-holes is steadily darkening until, as you reach a depth of twelve feet, all you see is inky black, so that below this depth you cannot tell excepting by looking at the depth gages whether you are twelve or thirty or two hundred feet down.

THE CREW AT WORK

Nor until you have gone down in a submarine and seen the crew at work can you say you have seen the limit to which it is possible to drill human creatures. No crack company of a regiment, no fire company in any of our big cities, not even the engine force on a man-of-war is under such discipline as the crew of a submarine.

The Navy Department and the men themselves realize that months are required before even the most capable group of ten can be made to work as a unit, perfect as clock-work. There is no time to "break in" crews when once war is declared, and for this reason the submarine service is continually and in-



ANOTHER VIEW OF THE OCTOPUS, DIVING.

set you can see and can feel as the nose of the vessel declines, just as you can feel with your eyes closed in which direction a see-saw you are standing upon might be tilted.

cessantly in war practice. Practice runs in the ordinary sense do not exist. Each time the boat stands out to sea she goes as if for business, the scenes you see being exactly like those that would

be enacted were the vessel bent upon actually sinking an enemy.

When a submarine leaves her pier under her own engine, orders come fast and furious; but once she is ready to dive they become almost incessant. In order to train men to keep in prac-

found roving. Each man is a mere cog, a human, thinking, intelligent cog, nevertheless, a mere cog.

What the submarine does, once it has disappeared, depends, of course, upon the captain. Steaming forward she can turn completely within



THE SUBMARINE CUTTLEFISH.

tice at their various duties and to perform these almost subconsciously, every maneuver which the vessel performs is repeated again and again. On a single afternoon's run, for instance, the boat may be brought from her light to her diving condition as many as a dozen times, so that actually the crew has no time *except* to attend to business. In the hand of each man rests the lives of his companions. More, it is conceivable how in the palm of a single man might rest the fate of the nation. Every man, from the captain who ranks as a lieutenant, to the able-bodied seaman taken from the forecastle of a warship, is at his post, tense, alert, with lips set and eyes and ears wide open, for the time being not a human creature but just a part of a marvelous machine. Not a word is spoken. Not an eye is

three times her own length and running backward she can head completely around in a single length. If the captain wishes, he can sink the deck an inch or a half inch or a foot or ten feet beneath the sea and proceed on an even keel, appearing from the deck of a man-of-war a mile and a half away like a chip of wood floating over the water; or he can go down ten feet, showing only the flags on the tips of his masts and proceed on such a level plane that the wire stay, running between mast-tops, is right down to the surface of the water. Or, if he wishes, he can rise and dive and rise and dive, "breaking" his conning-tower at intervals of half his boat's length, like a porpoise at play, while you sit still and feel yourself alternately climbing and coasting and climbing and coasting, rays of sunshine

alternating with the green water through the port-holes, and the splash and the seething of the water aboil coming from overhead.

THE EYE OF THE SUBMARINE

It is while running under water, of course, that the submarine encounters her gravest dangers, for the submarine is her own worst enemy. Largely, then, the captain must steer by compass and estimate distances covered by computing the revolutions of the propellers and he must take chances on being swept out of his course by unknown currents and cross currents. From the instant the slit windows of the conning-tower go under, these show only the green of the water, and when twenty feet depth is reached, looking through these windows is like trying to penetrate a sheet of jet. In order to enable the captain to see what is going on upon the water surface he is provided with a periscope which is nothing but a *camera lucida* on the principle of the "finder" of a camera, mounted on the top of a four-inch telescope-tube which can be extended twenty feet upward from inside the conning-tower, and down which the camera deflects against a six-inch diameter white enameled disk the diminutive images of whatever goes on above. The periscope, however, is useless when the boat dives deeper than the length of the telescope pipe, and, besides, it takes in only forty degrees of the horizon at a time, thus showing only a section at which it is pointed. For these reasons, likely as not, the captain may ignore the periscope entirely, using it only to practise running submerged toward a given point, while for actual navigation purposes he depends solely upon coming to the surface at intervals of two or three miles for a hasty look around. All of which shows in a measure the helplessness of the submarine—a terrific, dangerous, grim monster in itself, but one that can only partly see.

ON AN OCEAN BOTTOM

Up to now, however, you have not seen in full the possibilities of a submarine, for although in rivers or harbors the shallowness of the water limits the boat to traveling within ten or twelve feet of the water's surface, once at sea the vessel dives deeper.

As the nose of the boat touches the broad ocean you require neither slit windows nor periscope to tell you where you are. Caught in the swell of the sea, the boat heaves and falls, heaves and falls, and unless you have your sea-legs on, you are as apt to be seasick in a submarine as you

would be inside any other vessel, or more so. None, not even the most hardened submariner aboard, covets the sensation, and to overcome it the vessel dives deeper, twenty or twenty-five feet down, at which depth even the strongest wave-motion on the surface cannot be felt. Overhead might be seas mountain high threatening even a *Deutschland* or an *Adriatic*, yet twenty-five feet beneath the ocean surface you would proceed unmolested as if traveling beneath a mill-pond.

But twenty-five feet beneath seas is by no means the limit to which your boat can dive; in fact, at this depth she has not begun to dive. If your captain wishes, within two minutes he might take you down two hundred feet—fifty feet deeper than the most skilled deep-sea diver dares to venture—and where against every square inch of the surface of your boat there is a crushing pressure of more than 133 pounds. This, in truth, is one of the tests the government insists upon. If desired, your boat might dive to this depth or to any intermediate depth, and lie perfectly still like a gigantic fish of prey. Or within this depth limit she might come to rest against the very ocean bottom, landing light as a maple leaf wafted down upon a lawn.

Sitting inside a submarine on an ocean bottom you would be no more conscious of the enormous water pressure without than if you were going to sleep in your own bed. You might remain twenty-four hours under water without coming up, using only the natural air supplied in the boat without feeling the least uncomfortable. If you wished, you might remain down four or five days, tapping the air tank as you needed a fresh supply of air. In the meantime you would bunk over the torpedoes and torture yourself by letting your imagination loose to your heart's content, or you might read by electric light or play cards or dominos or checkers, the cook serving you with coffee and canned things that can be heated on an electric furnace without causing too much smoke, and making the air disagreeable to breathe.

Lying there, beneath the water, you are indeed cut off from the world. Hurricanes, typhoons, snow or sleet storms and blizzards might rage above you, and you never would know it. The entire American navy might assemble over your head and fire one simultaneous, ear-splitting, earth-quaking salute that would be heard twenty miles away, but you would not hear it. Nothing would come to you save the underwater noises: the thudding of propellers of steamers overhead, the chafing and banging of spars on decks of a wrecked vessel not far off, the grind and the crunch of your boat's keel scraping the sands.

THE SUBMARINE IN ACTION

INTERESTING though it may be to lie in a submarine two hundred feet down on an ocean bot-

“stunts,” even though awaiting the arrival of an enemy off a sea-coast. Then, cruising light, the boat would hover on one side of the lane by which the hostile ships must enter, sighting a war-ship eighteen miles distant, long before she herself could be detected by powerful glasses.

Full speed ahead the submarine would dart, laying her course to intercept the enemy, letting herself down as she drew nearer until she is awash at two miles distant. Then, torpedoes in tube, electric motors whirling, and crew at fever heat, down she goes until within one and one half miles of her prospective victim. “Porpoising” at intervals of three fourths of a minute, breaking her conning-tower for five seconds, she would proceed until within eight hundred yards, where she would rise to the surface, head her nose at the broadside of the enemy, let drive her torpedoes, drop under at once, listening for the frightful crash as the dread missile explodes its one hundred and ninety pounds of guncotton against the hull of the ship.

The United States submarine in action you never will see unless you get into the service. During peace time you can visit any of our navy yards and they will show you through the battle-ships, cruisers, gun-boats, and any other boat, from stem to stern; but about the secrets of our



SIGHTING THE ENEMY WITH A PERISCOPE.

tom, this is a test which the Navy Department insists upon only as a practical test to insure that your boat is structurally of a certain standard. Ordinarily, even during war time, the submarine would not be called upon for such circus

submarines the Department is jealous. It is like having teeth drawn to get a permit to go down in one, and your camera is barred. For the one dreaded, unknown quantity in our next naval war will be the devil-fish of our Navy, the submarine.

HOW KNIVES CUT

BY C. H. CLAUDY

WITH PHOTOMICROGRAPHS BY THE AUTHOR

WHAT makes a sharp knife cut, and a dull one hard to use? At first glance it would seem that the thinner the sharp edge, the easier the knife would cut, and in a measure, this is so, yet there are exceptions. If you want to carve a roast of meat and are offered the choice of a sharp carving-knife or a sharp razor, obviously you will choose the former. Yet the naked eye can see that the edge of the carving-knife is much thicker than that of the razor. When you come to the bone, it is not a knife, no matter how sharp, that you want, but a saw, as saws have very thick edges, provided with teeth.

Another puzzle—why, after a penknife is carefully sharpened on a stone, will it sometimes hold its edge for a long time and, again, get dull in a day?

Almost without further words, the little pictures answer these questions, once you know what they are. They are photographs of knife-edges, taken through a powerful microscope, which has magnified the edge so much that it no longer seems a smooth edge but a rough, irregular saw. And that is the secret—knives, no matter how carefully sharpened, are little saws; the grinding away of the steel, done by the stone, is not an even work, but when the edge gets thin, is a process of tearing away tiny bits of steel by the grit of the stone. This tearing makes the teeth. A fine stone makes fine teeth, a coarse stone coarse teeth. A carving-knife, used on meat, is sharpened on a coarse stone or a steel, and has coarse teeth, although its edge is thick. Its action in parting the meat is more that of a saw than a fine wedge. No matter how soft it may be, it will not cut easily unless it is drawn over the meat and not simply pressed down. A razor, however, with its paper-like edge, will cut into flesh with a simple pressure—it is a wedge dividing the fibers of flesh just as a wedge of iron divides the fibers of the log it splits. But a razor is a saw, too, only, as it is ground on the finest stones and later finished with a leather strap, its teeth are very fine indeed—hundreds and hundreds to the inch of blade. In the original photomicrograph, as I made it, the bit of razor which was under the lens was only one one-hundredth of an inch across, and you can count as many as twenty-five

irregular teeth in this space. Here, also, is the explanation of what some people consider a fancy—that one razor will cut better on a certain beard than another equally sharp. Obviously, the tougher the beard, the finer the teeth must be to cut without “pulling,” and a “pulling” razor is one which has teeth too coarse for the hair it aims to shave.

When you sharpen a jack-knife on a grindstone and finish it up on an oilstone, you have a sharp edge for a while—for a *long* while, if you have done the job rightly. But if you have ground with the blade very flat on the stone and the blade is, consequently, very thin indeed near its edge, you will probably have made what we call a “wire-edge.” One of the photographs shows this wire-edge. The steel has been cut into little saw teeth, it is true, but they are so thin that they break easily—how thin the steel is can be guessed from the little holes in the edge



THE EDGE OF A NEWLY HONED RAZOR-BLADE.

(Greatly Magnified.)

which have been torn by some extra large and sharp piece of grit in the stone. A wire-edge is very sharp, for a short time, but the teeth break off with every use of the knife, and, before you know it, only a jagged edge is left, which is neither sharp nor smooth.

Don't hold a knife flat on the stone—hold it at an angle so that from an eighth to a quarter



A PROPERLY SHARPENED PENKNIFE.

of an inch of blade is being ground, and when you put it on the oilstone, hold at the same angle. This will give just as fine teeth, but they will be thicker at their base than those made the other way—they will not break off so quickly and consequently the knife will stay sharp longer and may be given harder usage.

A saw, such as is used on wood, may be taken as an exaggerated knife. When you see a carpenter cut across the grain he takes a finer toothed saw than when he rips with the grain. *Across* the grain, he meets with the resistance of the fibers, which catch in the teeth; *with* the

grain there is less of this action and a coarser tooth can be used with better results. Knives are just the same—a knife may be very sharp for some kinds of work and very dull for others—for instance, the carver and the razor for the meat-cutting referred to at the beginning. The carver is sharp for the meat, where much pressure and little resistance are to be found, but imagine trying to shave with one! Hair is very tough indeed, and where so little pressure can be used as in shaving, the sharpest kind of a knife is required—which means only with the very finest and thinnest kind of teeth.

Have you ever cut yourself with a piece of paper? The edge of a piece of glazed paper looks much like that of a knife under the microscope. Of course, the little teeth have not the strength of steel, but if the edge of the paper is drawn swiftly over the finger without much pressure, that peculiar property of matter called inertia comes into play, and the tender teeth have cut the flesh before they are broken. The same property it is which allows a candle to be shot through a one-inch plank, or permits a bullet to pass through a pane of glass without shattering it, leaving only a clean, round hole.

I wish I had space to show you some photomicrographs of the knives of insects; certainly they carry knives, some of them. The horse-fly, for instance, has a ferocious set of lances, compared to which a razor is as a saw to a pocket-knife. The little teeth made by nature are so small, so even, and so sharp, it is no wonder that the little insect can cut (bite) his victims, without needing more pressure than his tiny weight easily affords.



A "WIRE-EDGE" ON A POCKET-KNIFE.



A BIT OF THE SCENERY WHERE THE NORTH END OF THE COMPASS-NEEDLE POINTS SOUTH.

To travel northward you must follow the south end of the needle.

THE COMPASS

THE popular idea of the compass is that it is an instrument having a freely moving needle which points to the north pole. But the needle points to the north pole when the compass is situated on the meridian of longitude that runs through the north magnetic pole. The real (or geographic) north pole and the magnetic north pole are not in the same place.

The magnetic north pole, toward which the compass-needle really points, is situated in the northern part of Canada, in northern latitude $70^{\circ} 5'$ and longitude $96^{\circ} 43'$ west from Greenwich. It was first visited in 1831 by Sir James Ross. The southern magnetic pole is in a corresponding position in the antarctic region. It was discovered by Sir Ernest Shackleton's expedition to be latitude $72^{\circ} 25'$ south and longitude 154° east.

These magnetic poles are not stationary. The northern one is slowly moving westward along the seventieth parallel, and in the course of three or four hundred years will probably have encircled the geographic north pole and returned to about its present location. Of course the southern magnetic pole follows a corresponding course about the geographic south pole.

In such cities in the United States as Omaha, Sioux City, Topeka, Galveston, etc., the compass-needle would point about in the direction of the north star and the north pole that Commander Peary reached. This geographic pole is about fifteen hundred miles north of the magnetic pole, toward which the needles of all compasses point.

When you get to the east or the west of the meridian that runs through these cities, the compass-needle will point a little east or west of north, according to where you happen to be.

You can see that if you go eastward of this meridian the needle will point a little *west* of true or geographic north, and if you go west of the meridian the needle will point a trifle *east* of north. Reference to the globe illustration on the next page, will make this plain. Say you have traveled as far eastward as New York city. A glance at the compass placed there will show about how much the needle fails to point to the true geographic north, for it is the *magnetic* pole that attracts it. If you traveled due north (along the meridian) from New York city, your needle would swerve more and more toward a westerly direction until you got to the seventieth parallel, on which the magnetic pole is located, when the needle would point due west; and if you continued north on the same meridian, the needle would point southwest; and so on. If you went north through San Francisco till you reached this parallel, the needle would point due east, as you can see from the compasses, in Fig. 2, located at these points. But suppose you left Omaha and traveled due north along the meridian of the magnetic pole, what would happen? Several surprises would await you. When the needle was exactly over the magnetic pole it would act about as a piece of straw would act and remain pointing in any direction in which you placed it—provided, of course, there were no disturbing local magnetic influences. Now for the queerest surprise! If you wished to continue your journey northward (geographically northward) you would have to be careful not to go in the direction of the *compass's* north,

for after you have passed the magnetic north pole your needle *has swung around* and points to both the magnetic north and the geographic south pole.

The next surprise would be when you reached the exact or geographic north pole and stood on it, for at that point you would know that there could be no east or west—you would look only south, no matter which way you looked—but the compass would point to *its* north just the same, though its north would be really south, and south along only *one* meridian.

It may be interesting to know something about this queer compass of ours whose needle cuts such strange capers. What is it, how was it discovered, who discovered it, etc.?

First, the compass is an instrument for indicating how many degrees east or west of a certain chosen meridian any point may be. The name *compass* probably meant originally (as a Latin word, *compassus*) a circle (such as is made by the drawing-instrument called a *pair of compasses*), and was given to the magnetic instrument from the fact that its needle or card will encircle, or compass, the whole plane of the horizon and

tritic brass rings (shown in Fig. 3) so joined as to keep the compass horizontal, no matter what may be the position of the ship. The circular card is divided into thirty-two equal divisions, the four main ones of which are the cardinal points of north, east, south, and west. The card is balanced from a cup-shaped agate center resting on a hard-metal pointed pin. The magnetic needles, usually two or four, fastened on the under side of the card, are composed of magnetic rods formed of thin layers of steel or of bundles of steel wires. On shipboard the compass is inclosed in the top of a stand called a binnacle. In Ritchie's liquid compass the card floats on the surface of a liquid composed of alcohol and water.

Young folks may quite easily make a compass of this form. Magnetize an ordinary sewing needle by rubbing it on a simple, "horseshoe" magnet.

If a heavy needle is used, float it on a card or a slender strip of wood of the same or nearly the same length as the needle. If a light needle is used, and it is well rubbed by the fingers, or slightly oiled or greased, it may be carefully laid directly on the



FIG. 1.

In 1507 William Barlowe says regarding the compasses then in use by the East Indians:

"Instead of our compass they use a magnetic needle of six inches long and longer, upon a pin in a dish of white china earth filled with water. In the bottom thereof they have two crossed lines for the four principal winds."

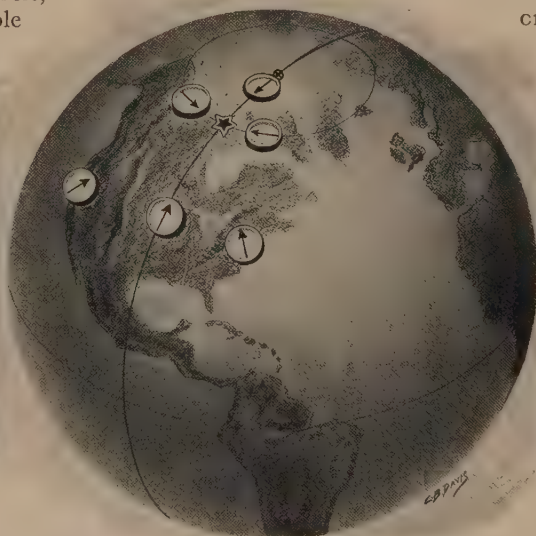


FIG. 2.

Compasses located at various points in the United States to show the variation of the needle.



FIG. 3.

A modern compass with part of the box broken away to show pins in the rings (gimbals) to keep the compass horizontal.

The principle is practically the same as in earliest compasses that were merely splinters of wood supporting magnetic needles. The disk is kept "water-level" by gravitation, while the needle points to the magnetic pole.

indicate the whole circle of possible horizontal directions of all points on the earth's surface.

The ship's compass is composed of three parts, as follows: first, the bowl or case; second, the card; and, third, the needle. The bowl is usually a brass receptacle suspended by two concentric

water. Though the needle is heavier than water, it will float because its weight is not sufficient (if either point is not tipped downward) to break the surface film of the water and sink.

The earliest accounts of the compass in Europe, it is thought, date back to the twelfth century.

THE BUILDING OF A "SKY-SCRAPER"

BY FRANCIS ARNOLD COLLINS

A QUIANT story is told of an old architect of the Middle Ages who prepared his plans for a great cathedral by sitting silently before its site for several years, smoking and meditating upon his work, before he drew a single line upon paper. The construction of a modern sky-scraper goes ahead astonishingly faster. The great steel structures, which are so characteristic of American ingenuity and energy, are built more after the manner of Aladdin's palace.

When the builders receive a definite order for such a structure it is a question only of hours before it will be actually under way. Before the architect has touched pen to paper, or perhaps before he has found time to give a thought to the design of the building, gangs of workmen have probably been rushed to the site to begin the preliminary work.

Should it be necessary to tear down a building it is quickly attacked, so that a few days after the order has been received the site will be marked by a cloud of dust. Even when a great steel structure is to be built upon a vacant lot the workmen are hurried to the place, the ground will be cleared, and the preliminary work will soon be well in hand. It is not a question of deciding upon a date a week or a month in advance to make a beginning. In most cases the work is actually under way before the sun is set.

Meanwhile a great staff of assistants lined before long rows of desks are busily at work figuring on the general form of the building, the weight the floors will support, the size and form of thousands of pieces of steel used in the construction, the quantity of stone, wood, and plaster, and the various materials employed. As soon as the builders know the height of the building, the number of stories, and its general form, they are able to order a great deal of the material needed, so that valuable time may be saved. It is not so much a question of saving material, or the cost of labor, expensive as these may be, but of saving *time*, which in busy streets, and when so much capital is involved, is very costly.

Each department is, of course, carried on by men skilled in their line, and these men must be gathered and employed. Orders must be sent to the quarries, perhaps hundreds of miles away, for the necessary stone. The lumber mills must also be told just what the orders will be so that

they may get to work. In addition there are plumbers, electricians, plasterers, carpenters, decorators, and hundreds of workmen to be engaged, all as far as possible in advance.

It is only a few years since the first work in erecting a building was to dig a deep hole for the



TWO MEN IN A BUCKET ENTERING A CAISSON.

foundations. If the building was to be a large one the excavation had to be very deep and wide. Large gangs of workmen with carts and horses were employed. It would frequently happen that great masses of stone must be blasted and, with the sand and dirt, carted away. Until this great hole was completed everything was at a standstill. To-day all this is changed. As soon as the site for a sky-scraper has been cleared for a modern steel structure, the ground is quickly filled with powerful machinery which would not

have been dreamed of by the builders of a few years ago. In many cases the site is actually flooded over with heavy timbers before the work commences. The machinery, which is quickly



"WALLING-IN." THE "FLATIRON" BUILDING,
NEW YORK CITY.

assembled, consists of powerful derricks, great drills, chutes, tall engines, odd-looking machines for mixing cement, and many curious steel frames to be used for building the odd chimney-like "caissons," as we shall explain later on. Such groups of machinery may be seen to-day in the most crowded streets of all large American cities.

For many centuries, in fact since the first stone buildings were raised by man, the general plan for building foundations has been much the same.

It consisted merely in building a wall deep enough and wide enough to support the structure above. When a very large building was to be erected, a cathedral for instance, the foundations were simply made deeper and wider. The plan of building foundations by means of caissons, which is an American idea, is of very recent origin. These foundations consist of pillars of artificial stone extending down into the ground, a great many of them for a considerable distance. These pillars, which form the foundation, are run down into the earth till they rest upon solid rock or at least a very firm basis. A building of twenty or twenty-five stories, for instance, usually rests upon foundations extending about sixty feet below the surface, and in some cases in New York, as far as eighty-five feet, depending upon the nature of the earth.

The foundations for the great steel structures are built by means of caissons in which the men can work under a great pressure of air. It is a very interesting sight to watch them, and the best of it is that any one may see them at close range from an adjoining sidewalk. The caisson is a hollow steel cylinder open at the bottom and just large enough to permit a man to work. The workman climbs down a ladder in this tube and digs away the earth at the bottom. As the earth is taken away the steel tube is gradually lowered. The earth is taken out by a bucket which is lowered and raised by a tall derrick at one side. As the caisson sinks, air is pumped into the compartment containing the man. This is to force back any water or dirt that might fill the hole from the outside as fast as the workman removes it from within. The pressure of this air is often so great that a man can work but an hour or so at a time. At the top of the caisson is a steel cylinder with an air-tight door at either end which serves as a kind of vestibule to the tube below. When one of the caisson workers starts to go to work he opens the door or lid at the top and climbs in, when the opening is once more tightly closed. This door or lid is air-tight. After the opening to the outer air has been closed the workman opens the door at the bottom of this steel compartment and lets in compressed air from the caisson below. It takes a few minutes to become accustomed to breathing this atmosphere, for the heavy air makes the head ring. As soon as the workman can do so he climbs down into the funnel below, closing the lower door of the steel ante-room as he does so. All this must be done in the dark. If the workman wishes to signal the outer world he may do so by striking the steel sides of his narrow prison



THE REMARKABLE "FLATIRON" BUILDING AT MADISON SQUARE, NEW YORK.

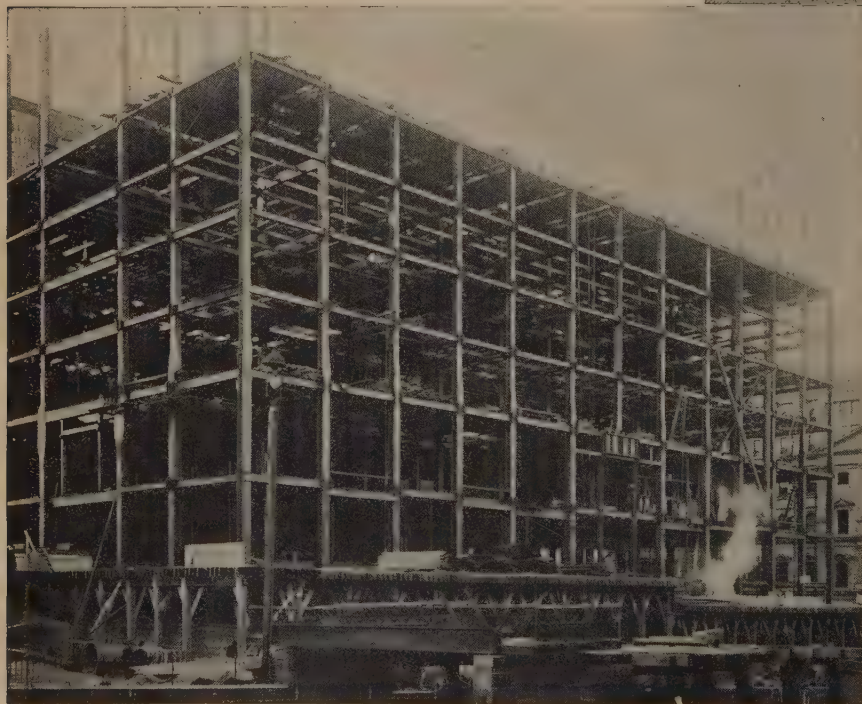
with his shovel. He usually signals in this way when the bucket is to be raised or lowered.

The work on one of these sky-scrapers goes forward so quickly and smoothly that few people realize how difficult is the problem to be solved. When the ordinary house is to be built, the bricks, stone, and lumber are piled about to be ready when needed. Now the steel structures with the tons and tons of material for all their great bulk are almost always built upon the busiest and most crowded streets of large cities and have literally no room to spread out. The streets and not even the pavements can be blocked even for a few hours. This fact, which few people stop to consider, makes the task exceedingly difficult. The work must be so arranged that the thousands of steel girders, the tons of bricks, stone, and lumber will be delivered only as it is needed and a day or two's supply at a time. Everything must move like clockwork. The directions for the work on such a building read like a time-table. If, for instance, the cement for the foundation should be but a few hours late in arriving, the entire force might have to stand idle. Should one of the steel girders be late or be delivered out of its turn, the iron-workers and all the men who depend upon their work would have nothing to do. The work goes forward so fast that every part depends upon something in one or more departments. And since as many as fifteen hundred men are employed on one of these steel structures at the same time, the loss of a day or so would cost thousands of dollars.

It has been asserted that Solomon's Temple, which was considered a great building in its day, was so constructed that when the materials were brought together they fitted



"THE CAÑON,"
WILLIAM STREET,
NEW YORK CITY.



perfectly, and so the structure rose without the sound of a hammer. A modern steel structure, which is vastly more complicated, is built in much the same way, every part, though it be made hundreds of miles away, fitting into its place. There is a great contrast, however, about the sound of the hammer, for the steel building must be securely riveted together. The builder first calculates exactly what each floor will be called upon to support and from



MEN WHO WORK ON "SKY-SCRAPERS."

Dangerous indeed is the life of the men who put together our towering buildings. Hundreds of feet in the air, often on the narrowest supports, they do their daily tasks with a coolness that makes the onlookers gasp. These pictures show men working upon the gigantic Metropolitan building, New York City. The picture on the upper left-hand side is that of the top of the tower of that building, showing the lightning-rod. The picture on the upper right-hand side shows a man at the top of the flagpole of the Hoffman House, New York.

this he will know the size and shape of the girders to be used. These he orders at some steel-works, probably hundreds of miles away, while he fixes the exact date when they are to arrive. It is the same with the stone, the bricks, the wood, and the many other materials. When these materials arrive, perhaps from all over the country, each piece will be marked in somewhat the same way as the material of Solomon's Temple, so that each may be put in its place.

The rapidity with which these structures rise is always a surprise. They seem to spring up almost in a day. As a matter of fact, under favorable circumstances, one of the buildings rises at the rate of about four stories a week. The finishing of them will of course take much longer. First the steel uprights are raised by the powerful derricks and swung neatly into place, while a gang of workmen, as many as can work together, quickly rivet and bolt the steel bars. The rivets are heated to a bright red heat, while the workman, sitting astride the cross-pieces, perhaps hundreds of feet above the street, hammers away till the great network rings like some giant smithy. In a few days a great forest of steel has sprung up, open on every side to the wind and weather.

The most astonishing thing about these huge structures is to watch them rising against the sky without walls of any kind. The steel network supports the building and the walls are merely a shell to be hung to this later on. And so we see these buildings with their walls beginning at the fourth floor and with the iron skeleton below entirely open. The steel buildings, however, are not the first to be built in this way, although the idea of doing so originated in America. The steel sky-scraper is, after all, the outgrowth of the old American frame house. Ordinarily a building rests upon its walls; the old-time frame house was held up by its frame, and the walls, whether they were of shingles or clapboards, were nailed on afterward. The quaint old-fashioned houses of a century ago would probably not claim to be relations of the gigantic steel buildings of to-day, though the family resemblance is unmistakable.

As quickly as the steel beams are in place in the sky-scrapers the masons are hurried to their work. The plan generally followed is to keep the stone-masons, housesmiths, and plumbers one floor behind the iron-workers, the carpenters one floor behind these, and, one floor behind these, in

turn, the plasterers, and so on till the work is complete. In every department of the work again are to be found ingenious time- and labor-saving devices. The scaffolding used by the bricklayers in walling-in, for instance, is well worth watching. The builders of a generation ago were obliged to set up a heavy scaffolding which had to be raised with great trouble or be added to as the wall rose. It was a common sight to see a large building completely covered with such staging. The scaffolding of to-day, on which scores of men may work at the same time, swings clear of the walls and is held by wire ropes which run to a point eight or ten stories above. These ropes are held by an ingenious device in the form of a pulley which makes it possible for one man to raise or lower the entire platform ten stories below. As quickly as a layer of stone or brick is laid the platform is raised so that not a moment is lost.

The hod-carrier of a few years ago has disappeared, as has his ladder, and in his place will be found a series of fast electric elevators which carry the material to the twelfth or twentieth story in as many seconds. The drilling of the holes for the plungers of some elevators is another curious problem. For every foot that the elevator rises in the completed building, a counter-weight plunger must go straight down into the ground. The hole into which this weight descends is usually about a foot in diameter, so that a hole of this size must be bored into the earth perhaps three or four hundred feet for each elevator. These holes are drilled with diamond drills which will pass through the hardest rock.

It might be possible to build sky-scrapers of stone or brick to the same height as the steel structures, but such buildings would be no safer, they would be vastly more expensive, and would take very much longer to put up. Then again the lower walls of a stone structure would have to be so very thick that there would be but little room left on the lower floors, or space for windows. The only question which remains is how long these buildings of steel will stand. The walls do not matter, for even if they should crack and fall away, they could readily be replaced, for it is the steel frame that carries the weight of the floors and their contents. And it chances that even this question has been answered, if at frightful cost, by the sky-scrapers which survived the great fire in Baltimore and the earthquake at San Francisco.



*Built
at a cost
of more
than
\$7,500,000*

*In style
it is a
combina-
tion of
Italian
and
French
Renaiss-
sance
archi-
tecture,
with
Gothic
steeples
ornament-
ing the
roof.*



*The
tallest
business
structure
in the
world,
55 stories
high, or
750 feet
from the
street level
to the
cupola.
It is 300
feet taller
than the
Great
Pyramid
of
Cheops.*



Photo. by Wurts Bros., N. Y.

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THE WOOLWORTH BUILDING, NEW YORK CITY.

TRICKS AND MAGIC

A MODERN MAGICIAN

BY TUDOR JENKS

WHEN you see a conjurer's wonderful tricks you are likely to wonder how he was clever enough to think of them all and to invent so many ways of mystifying his spectators. But you are giving the conjurer more credit than he deserves. It is as if one said, "The man who wrote the encyclopedia must have known everything!"

Just as no one man ever wrote a complete encyclopedia or dictionary "all out of his own head," no one man ever exhibited a whole entertainment of tricks invented by himself. Tricks and feats of skill in conjuring are handed down from one conjurer to another, and each new one learns from all the others.

Very probably some of the tricks still shown to-day once delighted the Egyptians who built the pyramids and now rest as mummies in our museums.

But some men so greatly improve upon what is taught them as to become entitled to the credit of originators; and one man so improved the art of conjuring as to be called "the father of modern magic."

This man was once a little French boy, the son of a watch-maker. He was born in Blois four days after Napoleon I. won the great battle of Austerlitz. During his boyhood he was attracted by his father's toolshop, and often had to be driven out of it. From a neighbor, an old army officer, the boy learned to make a number of mechanical toys and also invented new ones. This neighbor, Colo-

nel Bernard, had been a prisoner for many years and had amused himself by making these little toys; and he was so pleased by the ingenuity of the eight-year-old boy that he used to say heartily, "Why, the young scamp can make anything he likes!"

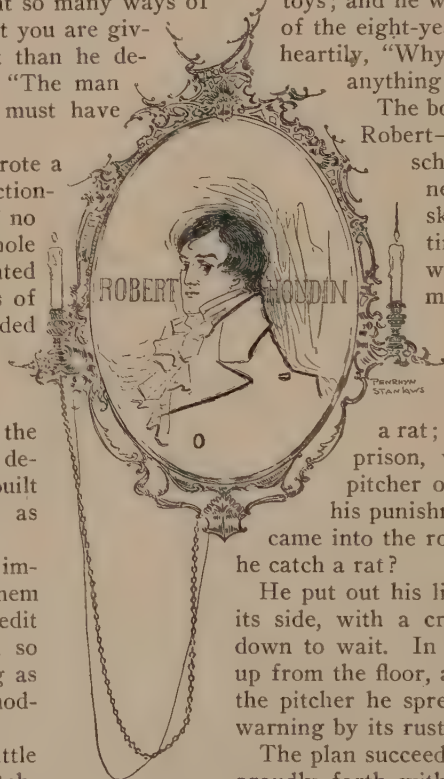
The boy—his name was Jean Eugène Robert—loved toy-making better than school, and says that a long illness gave him leisure to try his skill. Even at school he found time to make a cage in which were contrivances worked by mice. One day he made a pump out of quills (his quill pens, no doubt), and found it could not be driven by mere mouse-power. He longed to catch

a rat; and being shut up in the school prison, with only some bread and a pitcher of water, he was reconciled to his punishment by remembering that rats came into the room at night. But how should he catch a rat?

He put out his light, placed his pitcher flat on its side, with a crust of bread within, and sat down to wait. In his hand he held a brick dug up from the floor, and in front of the opening of the pitcher he spread out a bit of paper to give warning by its rustling when the rat entered.

The plan succeeded, and next morning he came proudly forth with his captive. But he had to hide the rat among his clothes, and as the clothes were gnawed the whole story had to be told to the head-master. A long lecture followed, and Robert promised to be good until he graduated—a promise he faithfully kept until he left school at eighteen.

During a short holiday, while wandering along



the Loire River, he witnessed the tricks of a traveling peddler, and eagerly bought a little book on conjuring, hoping to learn the mystic art. But he found the explanations harder to understand than the tricks themselves, and soon gave up these studies.

He became a copying clerk, but in his leisure preferred to copy exactly a mechanical snuff-box

found there than in his legal papers; and he made for the cage a number of moving tricks worked by the birds. At length the lawyer advised him to give up law and to follow his natural tastes, and persuaded Robert's father to apprentice the son to a watchmaker—much to Robert's delight.

Absorbed in his mechanical work, Robert was thinking little of conjuring when an odd accident turned his mind again in that direction. He went to buy a book on watch-making, and the busy bookseller did up by mistake two volumes about magical tricks—an error that was not discovered until Robert was at home.

As long as his candle burned the young man read his new books; and when, suddenly, the candle sputtered and went out, he was in despair. He tried in vain to sleep, but could not bear to leave the fascinating study. He rose, seized a pair of pincers, and, half dressed, went down to the street, meaning to "borrow" one of the lamps from the hanging lanterns that then lighted the streets. But just as he took it down, a baker came out of a shop and stood in his doorway smoking his pipe, while Robert was shivering behind a door-post not far away with the lamp hidden in his hat. At length the lamp set fire to Robert's hat, and had to be put out, and the young man at last returned to his room disappointed.

A week's study taught him all the books could impart, and then he learned he needed skill as well as knowledge. For ten francs a neighbor taught him to juggle with balls, and Robert at the end of a month could keep

that had been left in his father's shop to be mended. On its lid was shown a hare feeding; a hunter and dog appeared; click! the hunter shot at the hare, which ran away, pursued by the dog. When Robert had made the duplicate box, he showed it to his father; the father praised his skill, but strongly advised his son not to meddle with mechanics, but to learn a profession.

Sent into a lawyer's office, Robert was more interested in a cage of canary-birds that he

four going at once, and even read a book at the same time. He added other feats to this accomplishment, and practised constantly with cards, coins, and other little things—wearing a loose overcoat with big pockets so that he might practise while going about the streets. Having entered the service of another watchmaker in Tours, Robert gave amateur entertainments to his master's family.

Then, accidentally poisoned by a dish cooked



THE MAGICIAN, HIS SON ÉMILE, AND THE CUSTOMS OFFICER.

in a copper kettle, Robert feared he would die, and became so homesick that, before he was able to stand the journey, he started for Blois by stage. Becoming light-headed, he jumped out, and being unnoticed, was left in the road unconscious. He was picked up and cared for by a traveling magician named Torrini, who gave performances in a sort of gipsy-wagon that was built double and could be drawn out like a telescope, and thus formed a theater.



A STAGE MAGICIAN OF THE OLD STYLE.

For six months Robert went about with this kind old conjurer, learning his tricks and aiding in his performances. And when the gipsy-wagon was smashed in a collision, Robert gave entertainments until he could repay the old conjurer's kindness by setting him up in business once more.

It would take too long to tell all the history of the old magician,—you will read that some day for yourselves, perhaps, in the book Robert wrote about himself,—but among the tricks he performed was the “box trick,” where a man goes into a box or basket, which is sawed in two or pierced by swords, and then appears elsewhere unhurt. At this time Robert performed the

“omelet trick”—cooking eggs in a high hat. Once he burned the hat, and would have been disgraced except for a quick-witted assistant who substituted Robert's hat for the borrowed one, and put into the crown a note asking the spectator not to betray them, and promising a fine new hat next day. The secret was kept.

Robert, though fully determined now upon being a magician, returned for a while to watchmaking; but, while acting in some charades, he met a charming Mademoiselle Houdin,* and before long married her. Since his own name was a common one in France, Jean Eugène Robert took henceforth his wife's name in addition to his own, and he is known to the world as Robert-Houdin.

As his father-in-law was in a business connected with watchmaking in that city, Robert-Houdin went to Paris and assisted him, but kept alive his interest in conjuring by attending all the exhibitions that were given, and by frequenting the shop of an old man named Poujol, who sold magicians' apparatus; he thus learned many new tricks, and met the “professors of magic”—among others Jean de Rovere, who invented the word “prestidigitateur,” meaning “one ready with the fingers.”

Houdin (as we may now call him) learned in these days to dread the uneducated spectators more than those who knew more. He explains that the educated audience comes to be amused, while the uneducated spectators wish to prove their cleverness by seeing through the tricks of the performer.

Houdin also read all he could find upon the mechanical side of his preferred vocation, but he found little in books save fables and wonder stories. He studied all that was on record about the works of Jacques de Vaucanson—who had made a mechanical figure that played the trumpet, another that beat a tambourine, and a wonderful moving duck; and he was lucky enough to repair the duck, and thus found out just how its “wheels went round.” But the most astonishing contrivance he found was the famous “Automaton Chess-player” that had once set all Europe to guessing.

Houdin explains this trick. The figure was a Turk, apparently too small to hold a man inside, and it played chess successfully against the best players in the world—being rarely beaten. But the whole contrivance was a mere deception. The figure was moved by a Polish officer, a refugee who had lost both legs in battle, and was therefore able to pack himself snugly into the hollow figure or into the chest upon which it sat.

* This French name is pronounced “oo-dan”—only in saying *dan* you suppress the *n* sound.

While the inside of the Turk's body was examined the officer was stowed in the box below; and he climbed up into the Turk when the box was inspected.

Thus hidden, the officer played chess against Catharine of Russia while that Empress was offering a reward for his capture. It is said the imperial player cheated, whereupon the mechanical Turk lost his mechanical temper and swept the chessmen from the board!

Afterward Catharine ordered the figure to be left in her palace, M. de Kempelen being thus forced to carry off the real player in a packing-box. The next day (probably after the Empress had tried in vain to discover the "missing link") Kempelen explained that the chess-player required his own personal attention, and thus persuaded her to let it go!

A circumstance that helped to fool the public was the fact that the Polish officer wore artificial legs while out of the figure.

This chess automaton was once owned by Napoleon Bonaparte, came twice to this country, and in 1854 was burned in Philadelphia.

Another marvel that came under Houdin's notice at this time was a mechanical musical orchestra—a gigantic music-box. Having rashly undertaken to repair it, it was delivered to him as a tangled mass of fragments of metal. For a whole year he worked upon it, and finally was entirely successful—but was soon after attacked by a brain-fever that caused him to pass five years almost in idleness.

When completely recovered, Houdin set to work again at mechanics, and made several moving figures of his own invention. With these and the tricks he already knew, he hoped to begin his career as an exhibitor and performer; but hardly had Houdin planned out his little theater when his father-in-law failed in business.

Houdin took to mending watches again, and for some time was poor; but the invention of a clever alarm-clock that brought out a lighted candle after ringing the waking-bell, and the sale of several automatic figures—a dancer, a juggler, and singing-birds—restored his fortunes until he could once more proceed with his plans for a theater of his own in which to exhibit the best pieces of work he had made and to present his magical performances.

One automaton that he specially wished to complete before his public performances now absorbed all his time and labor; but when it was finished, Houdin might well be satisfied. It was a figure that wrote answers to questions and could also make drawings. But he made it *too* perfect. It was noiseless, and the public thought

it too simple to be wonderful. So Houdin let the wheels buzz a little,—to remind the spectators that it went by machinery,—and thereafter it was considered a marvel indeed. After this was done, he undertook to make a perfect imitation of a nightingale's song by clockwork; and after long study and hard work he was successful in this task also.

He sold these two contrivances for seven thousand francs—fourteen hundred dollars.

His writer, which Houdin named "Auriol," was borrowed from its buyer and exhibited in a Paris exposition in 1844. Louis Philippe, then King of the French, brought the Duchess of Orléans and her son, the Comte de Paris, to see



THE MAGICIAN AS HOUDIN PRESENTED HIM.

the little figure; and, in answer to the King's question as to the number of inhabitants of Paris, the figure traced with its pencil the figures 998,964 (about one third of its present population, by the way). The King said the new census would soon show more, and Houdin cleverly claimed that when the census came out his writer would probably be wiser—an answer that amused the King. Then, after Auriol had supplied a rhyming word to an incomplete verse, the little prince was asked to choose from some cards the name of an object for the automaton to draw. The little Comte de Paris chose a card, and found it

called for a crown—which was a pretty compliment the skilful conjurer brought about.

The automaton had nearly completed the drawing when its pencil broke. Houdin stepped forward to put in a new one, but the King good-

day, and in the middle of the performance, one by one, all his spectators fell asleep. Even the performer at last dozed also, and his pianist, thinking all was over, went out. This was the signal to the gas-man to put out the lights, and



HOUDIN AND THE ARAB CHIEF IN ALGERIA.

naturedly said that the little prince could finish the drawing for himself as a lesson.

This exhibition brought Houdin a silver medal, and also made him somewhat known to the public.

Houdin was at last able to build the little theater for which he had so long planned, and, when it was complete, he gave a "dress rehearsal" before a few friends. It was a hot June

for two hours there was darkness and silence, except for a snore now and then.

Houdin, awaking, feared he had lost his sight; but his outcry aroused the friends, and, to their great amusement, all was soon explained.

His first public performance, July 7, 1845, was entirely successful; but the conjurer was so nervous that his heart failed him, so he took down his notices and resolved to abandon the ex-

periment. A "friend" called and assured him that he was very sensible to give it up—that he could never hope to succeed; and, stung by this cruel kindness, Houdin at once determined to go on at any risk. The advertisements were again posted, the performances resumed, and thenceforth his success was almost uninterrupted.

Among his tricks, none so much mystified the audience as what he called "second sight." He speaks in his book as if it were his own invention, and it may have been, in spite of its having been practised in a crude form some sixty years before by another performer. Certainly Houdin wonderfully improved it, and made it a spectacle all Paris talked of.

Houdin's son, Émile, with bandaged eyes, would clearly describe any article the audience handed to his father; and when the people found that whatever they brought—ancient coins, foreign books, queer tools, minerals—was quickly named and told about in detail, they saw that there were no accomplices, and considered the trick a marvel. Then the theater was crowded whenever opened.

Houdin needed quick eyes and a ready brain to solve the puzzles brought to him; for of course the son could tell only what the father reported to him by secret signals. One evening, for instance, a man suddenly covered the number on the back of the stall he sat in, and defied the conjurer's son to give the number. Houdin, at the moment, of course did not know, and he pretended to object; he said his son only saw through the father's eyes, and so, of course, could not be expected to tell a number unknown to the conjurer himself. But while Houdin talked, and while the spectator was boasting to his friends that he had puzzled the famous magician, Houdin had made a rapid calculation, had found the number, and conveyed it to his son, who said, "It is No. 69," to the complete confusion of the "smart" man and the delight of the audience.

How did Houdin find out the number?

He says that he knew theaters were arranged with even numbers on one side, odd on the other. He counted ten seats in each row, twenty across the theater; commencing at the right with 1, the second row would begin with 21, the third with 41, and so on. His questioner was in the fourth row and had the fifth seat from the end; and beginning with 61 at the fourth row, he counted "61, 63, 65, 67, 69," and then announced the number correctly as 69.

By continual study, the conjurer and his son learned all about the strange things audiences selected to puzzle them, and it was a very out-

landish object about which they were not better informed than the spectators themselves. Long lists of names and dates were committed to memory, and the boy Émile was also trained to remember whatever he saw, even in a single glance. Father and son would often walk rapidly past a shop-window, and then see which could write down the best list of what was within. Houdin says his son soon beat him at this game.

Going once to give an entertainment at a private house, they entered through a library. Houdin told Émile to notice the books in passing. The boy gave a rapid glance at the case. Later in the evening, the conjurer announced that his son could "read through the wall"; and asking for a book, Houdin was led out into the library. He at once called out to his son and asked the name of a book he touched. The name was given, and without further question the young second-sight performer gave the names also of volumes above, below, and on each side of the one touched, repeating a dozen titles. All these he had remembered from one glance.

It seemed witchcraft then, and seems hardly credible now; and yet there was in a New York paper not long ago an account of the examination of a class of young women who, after a short glance, told exactly what was written in sixty-four squares of a blackboard—though the board had been shown only a moment or two. *All* the girls had learned this art, and all of you can learn it by practice. But Houdin *discovered* that it could be done, and it is such discoveries that prove him a genius.

While making a foreign trip, Houdin was stopped at a custom-house, and would have been put to much trouble except for a clever trick that won him the favor of the customs officer. The officer asked for a specimen of his talents; and Houdin called to his son, who was playing not far from where the men stood.

"What do you see in this gentleman's pockets?"

"A blue-striped handkerchief," replied Émile.

"He might have seen that," said the astonished officer.

"What is under that?" inquired Houdin.

"A green spectacle-case," replied Émile, promptly.

"What next?"

"A lump of sugar saved from his coffee."

This last answer convinced the officer that Houdin was a great conjurer, and he let the baggage pass. The trick was simple, however; for Houdin had slyly picked the man's pocket, and then replaced its contents.

The foreign trip was a failure, for Houdin was robbed by his manager, and he returned to Paris,

resuming his "Soirées Fantastiques," as he called them. These "fantastic evenings" were very different from what other conjurers then offered. While they wore queer robes covered with magical emblems, and filled the stage with heavily curtained and tasseled tables, Houdin was in simple evening dress, and had only a light stand, undraped. But in that light, flimsy table were hidden ten spring-rods moved by strings running down its slender legs and attached to a keyboard

wonderful trick. He borrowed six handkerchiefs. Then those present wrote on cards where they chose to have the handkerchiefs appear. The King drew three. One suggested, "Under the candelabra on the mantel"; a second, "In the dome of the Invalides"; a third, "Inside the box of the last orange-tree in the avenue." Choosing the third, the King sent servants to guard the box. Houdin put the handkerchiefs under a glass bell, waved his little magic wand, and raised the bell. A white dove walked out.

Then an attendant was sent by the King to open the box, and returned with a rusty old chest. The King asked whether the handkerchiefs were in the box, and Houdin assured him they were. The chest was unlocked with a key taken from the dove's neck, and out came a musty, fusty parchment certifying, under the seal of the noted Cagliostro (a well known magician of a hundred years before), that the six handkerchiefs had been put there in 1786 for the purpose of a trick to be performed by M. Robert-Houdin before Louis Philippe, etc.

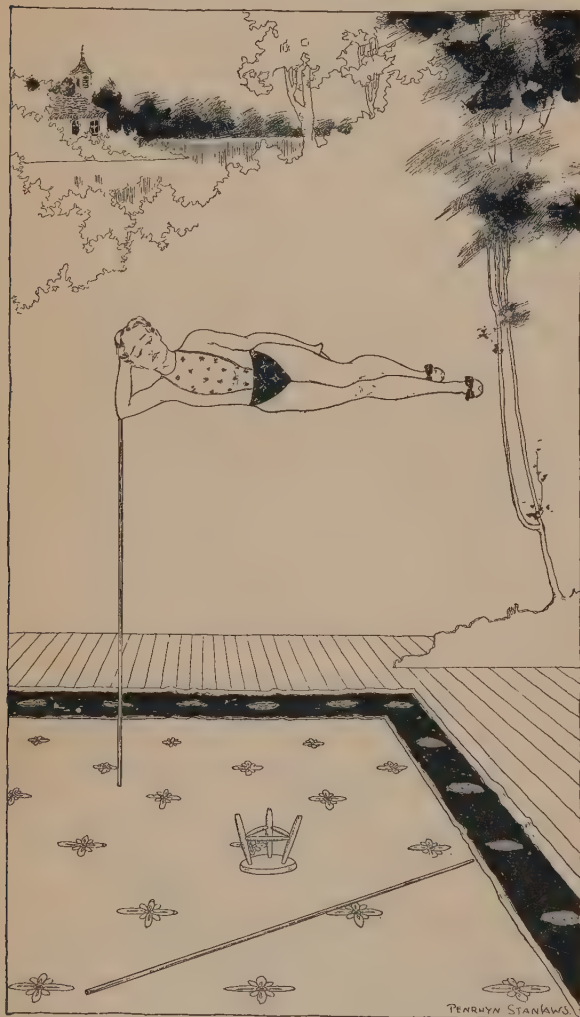
Beneath the parchment was a packet sealed with Cagliostro's signet, and in the packet were the handkerchiefs!

The next year Houdin brought out another wonder; for he believed a magician could not afford to rest on past triumphs. At this time ether was much talked about, being a new discovery, and Houdin asserted that he had discovered a means of making a body float in the air—"ethereal suspension" he termed it.

He would lead his little son out upon the stage and mount him on a stool. Then a light cane was put under each elbow, and, with much hocus-pocus, the magician pretended to hold a bottle of ether to the child's nose. After a moment the magician moved out the stool, and the boy seemed to rest securely on the canes. A cane was taken away, and still the boy hung in the air. Then the child was lifted sideways until he seemed to recline gracefully upon nothing except the light cane under one elbow.

Like Columbus's (or Brunelleschi's) egg trick, it is easy when you are shown how. The light cane concealed a steel rod whose lower end entered a socket in the stage, and whose upper end fitted a light steel frame fitted to the boy's body under his stage costume, and thus held him securely.

It is believed that this trick was invented by the Chinese—but then, you know, they claim everything. The later magicians improved it by



"ETHEREAL SUSPENSION." ONE OF HOUDIN'S ILLUSIONS.

managed by a skilful assistant. These ten rods, pressing against the feet of different objects set on the stand, truly worked wonders.

In November, 1846, King Louis Philippe "commanded" Houdin to perform at St. Cloud, and the magician crowned a successful evening by a

seeming to remove even the last cane, which was done by making the polished steel bar within the cane triangular, so that it reflected the stage-curtains at the sides. As these were like the curtains behind the figure, the bar could not be seen.

But in 1848 a revolution in France drove out the King of the French, unsettled public affairs, and put an end to all theatrical business, including Houdin's. The conjurer went to England and gave many performances, appearing before Queen Victoria and Prince Albert, the Duke of Wellington, and Louis Napoleon—who was soon to become first the President and then the Emperor of France.

Going to Manchester, the manufacturers' operators came in crowds to the show; but when Houdin began to speak French they roared out: "Speak English!" and Houdin delighted them by good-naturedly doing his best in broken English, stopping every now and then to ask, "How do you call this?" when he was at a loss for a noun.

After fifteen performances Houdin had to give place to the great singer Jenny Lind, and he traveled about to different towns until summoned to give an entertainment before the Queen at Buckingham Palace.

In 1849 Houdin returned to Paris, and after three years he retired from the stage to give his time to electrical and scientific inventions. One suggestion he made has since been carried out—the sending of correct time by electricity, so that all clocks may be made to agree. The United States sends every day a signal when the official clock points to noon, and this has grown to be a most important service.

But the French government called upon the retired conjurer for one more appearance. It was when the French had conquered Algeria, and were trying to rule the country. Native "prophets" or magicians, known as Marabouts, were stirring up insurrections and exciting the Arabs by pretended miracles. Houdin was called to go to Algeria and to excel these native performers, so that the intelligent chiefs might see the false prophets outdone by a mere performer in thea-

ters, and so that the ignorant Arabs might believe the French magician more powerful than their own.

Houdin consented, and gave a brilliant exhibition of his powers. How the Arabs stared to see cannon-balls and flowers lifted from an empty hat, an empty bowl filled mysteriously with smoking coffee, and money thrown across the theater into a closed glass box swinging from a long cord!

Then Houdin declared he could make the strongest Arab powerless in a moment. A brawny chief leaped upon the stage and defied him. Houdin pointed to a small metal box and told the Arab to lift it. It was lifted with ease, and the Arab sneered. Houdin waved his wand above the chief's head, telling him to try again. Pull and tug and strain as he might, the little box never budged; nor was this strange, for an electromagnet was holding it down. The Arab let go and paused for breath, and returned to the struggle with renewed strength. But as soon as the poor chief touched the box, he began to dance and yell and writhe; for the electric current had been connected with the handles.

Another Arab—a Marabout—leaps upon the stage, and says he will shoot the French magician. Houdin permits the Arab to load a pistol and fire it at him—and then shows the bullet in an apple he has held in his fingers. And after Houdin has put a big fellow on a table, covered him with a cone, and then caused him to disappear, the native audience waits for no more, but rushes panic-stricken to the door, only to meet the missing Arab from the cone.

A trip in Africa followed, then a stormy voyage to France, and Houdin's career as a public performer was at an end. He died in 1871.

Before the day of Robert-Houdin most professors of white magic were mere mountebanks; this Frenchman made the "prestidigitateur" a gentleman whose finer art was concealed by simplicity. In his performances there was no vulgarity, no cruelty, nothing debasing. He amused and delighted thousands, and was always an upright, honorable gentleman.



TWELVE TRICKS WORTH TRYING

HOW TO LIGHT A CANDLE WITHOUT TOUCHING IT

HAVING allowed a candle to burn till it has a long snuff, blow it out suddenly. A wreath of smoke will ascend into the air. Now if a lighted match is put to the smoke at a distance of three or four inches from the wick, the fire will run down the cloud, and relight the candle.

HOW TO BOIL WATER IN A PAPER BAG

"HERE is a sheet of note-paper; can you boil me a little water in it?"

This would appear to be a thorough puzzler, yet it is exceedingly easy to do. Fold a piece of paper so that it will hold water, and suspend it above the flame of a lamp. The water will so readily take up all the heat that there is none left with which to burn the paper, and presently it will bubble and give off steam.

LIFTING A BOTTLE WITH A STRAW

It is quite easy to lift a bottle with a straw, although the straw seems so frail as to be incapable of supporting any considerable weight, as indeed it would be but for our method of placing it. We select a straw that is uninjured—that is, one that has not been bent or broken in any way—and, bending the thicker end of it, we insert it in the neck of the bottle so that the straw rests in the bottle as shown in the picture. The bend of the straw must be on the angle formed by the side and bottom of the bottle. If we then raise the straw gently and steadily, the bottle will be



lifted and supported. A quite heavy bottle may be lifted in this very simple way.

A CURIOUS CANDLE

To perform this trick, get a piece of candle, and weight it by sticking a nail into the lower end.

The nail must be just heavy enough to bring the top end of the candle, when placed in a glass of water, level with the surface, without allowing the water to touch the wick.

If you now light the candle, it will burn down to the end, in spite of the fact that it is surrounded by water.

This appears at first sight to be very improbable, but you will see, on thinking it over, that it is quite possible; for although the burning of the candle seems to bring the wick nearer to the water, yet, on the other hand, as the candle burns it becomes lighter and rises gradually.

ODD OR EVEN; OR, THE MYSTERIOUS ADDITION

You take a handful of coins or counters, and invite another person to do the same, and to ascertain privately whether the number he has taken is odd or even. You request the company to observe that you have not asked him a single question, but that you are able, notwithstanding, to divine and counteract his most secret intentions, and that you will, in proof of this, yourself take a number of coins and add them to those he has taken, when, if his number was odd, the total shall be even; if his number was even, the total shall be odd. Requesting him to drop the coins he holds into a hat, held on high by one of the company, you drop in a certain number on your own account. He is now asked whether his number was odd or even; and, the coins being counted, the total number proves to be, as you stated, exactly the reverse. The experiment is tried again and again, with different numbers, but the result is the same.

The secret lies in the simple arithmetical fact that if you add an odd number to an even number the result will be *odd*; if you add an odd number to an odd number, the result will be *even*. You have only to take care, therefore, that the number you yourself add, whether large or small, shall always be odd.

THE BALL OF BERLIN WOOL

An easy and effective mode of terminating a money trick is to pass a marked coin into the center of a large ball of wool or worsted, the whole of which has to be unwound before the

coin can be reached. The explanation is absurdly simple when the secret is revealed. The only apparatus necessary except the wool (of which you must have enough for a good-sized ball) is a flat tin tube, three to four inches in length, and just large enough to allow a quarter to slip through it easily. You prepare for the trick by winding the wool on one end of the tube, in such manner that when the whole is wound in a ball, an inch or so of the tube may project from it. This you place in your pocket, or anywhere out of sight of the audience. You commence the trick by requesting some one to mark a quarter, which you must exchange for a substitute of your own, and leave the latter in the possession or in view of the spectators, while you retire to get your ball of wool, or simply take it from your pocket. Before producing it, you drop the genuine coin down the tube into the center of the ball, and withdraw the tube, giving the ball a squeeze to remove all trace of an opening. You then bring it forward, and place it in a tumbler, which you hand to a spectator to hold. Taking the substitute coin, you announce that you will make it pass invisibly into the very center of the ball of wool, which you accordingly pretend to do. You then request a second spectator to take the loose end of the wool, and to unwind the ball; when he has done this, the coin falls out into the tumbler.

THE CAPITAL Q

TAKE a number of coins or counters, say from twenty-five to thirty, and arrange them in the form of the letter Q, making the "tail" consist of some six or seven counters. Then invite some person (during your absence from the room) to count any number he pleases, beginning at the tip of the tail and traveling up the *left* side of the circle, touching each counter as he does so; then to work back again from the counter at which he stops (calling such counter *one*), this time, however, not returning down the tail, but continuing round the opposite side of the circle to the same number. During this process you retire, but on your return you indicate with unerring accuracy the counter at which he left off. In order to show (apparently) that the trick does not depend on any arithmetical principle, you reconstruct the Q, or invite the spectators to do so, with a different number of counters, but the result is the same.

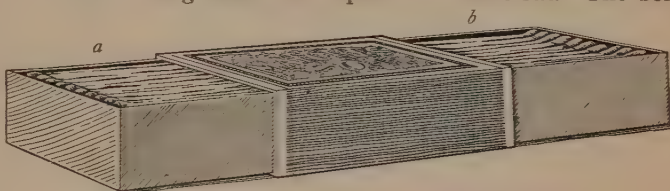
The solution lies in the fact that the counter at which the spectator ends will necessarily be at

the same distance from the root of the tail as there are counters in the tail itself. Thus, suppose that there are five counters in the tail, and that the spectator makes up his mind to count eleven. He commences from the tip of the tail, and counts up the left side of the circle. This brings him to the sixth counter beyond the tail. He then retrogrades, and calling that counter "one," counts eleven in the opposite direction. This necessarily brings him to the fifth counter from the tail on the opposite side, being the length of the tail over and above those counters which are common to both processes. If he chooses ten, twelve, or any other number, he will still, in counting back again, end at the same point.

The rearrangement of the counters, which is apparently only intended to make the trick more surprising, is really designed, by altering the length of the tail, to shift the position of the terminating counter. If the trick were performed two or three times in succession with the same number of counters in the tail, the spectators could hardly fail to observe that the *same* final counter was always indicated, and thereby to gain a clue to the secret. The number of counters in the circle itself is quite immaterial.

THE INEXHAUSTIBLE MATCHBOX

THE "matchbox" trick is as follows: An ordinary "safety" matchbox of small size, after being shown full, is completely emptied, the matches being turned out upon the table-cloth. The box



THE MAGIC MATCHBOX THAT ANY BOY MAY MAKE.

is closed. When again opened, it is found to be full of matches, as at first. These also are turned out. Once more the box is closed, and once more, when opened, it is found to be full. The third batch of matches is shaken out, after which the operator endeavors to put them all back again, but without success, for, even when packed as closely as possible, the box cannot be made to accommodate more than half of those on the table.

The secret lies mainly in the fact that the matchbox used, though ordinary in kind, has undergone a special preparation, as follows:

With a sharp penknife, split six or seven of the matches down the middle. Take out the "drawer" portion of the box, turn it over, and smear the under side with glue; then lay the half-matches, all pointing the same way, side by side upon it. If this is neatly done, the inverted drawer thus treated will have all the appearance of a full one right side up. When the glue is dry, reverse the drawer again, replacing the matches that it contained. Push it halfway only into the outer case; and into the opposite end of the same case push the drawer portion, also full, of another box. You will thus have two drawers in one case, the appearance being as shown in the picture. The unprepared drawer is represented by *a*; the prepared one by *b*. This box, at a suitable moment, the owner brings forward as if it were one in ordinary use, taking care to keep the end *b* well covered by his right hand. Making some remark about the strange properties of matches of this brand, he offers to give an illustration of one of them. So saying, he shakes out the visible matches upon the table, and shows the box empty. Remarking, "Now I will just close the box again," he brings the left hand up to it, as if merely to push in the drawer, but, as a matter of fact, presses in *b* from the opposite end, thereby pushing out the empty drawer into his left hand, where it remains concealed. He holds up the box in the right hand, showing it fairly closed.

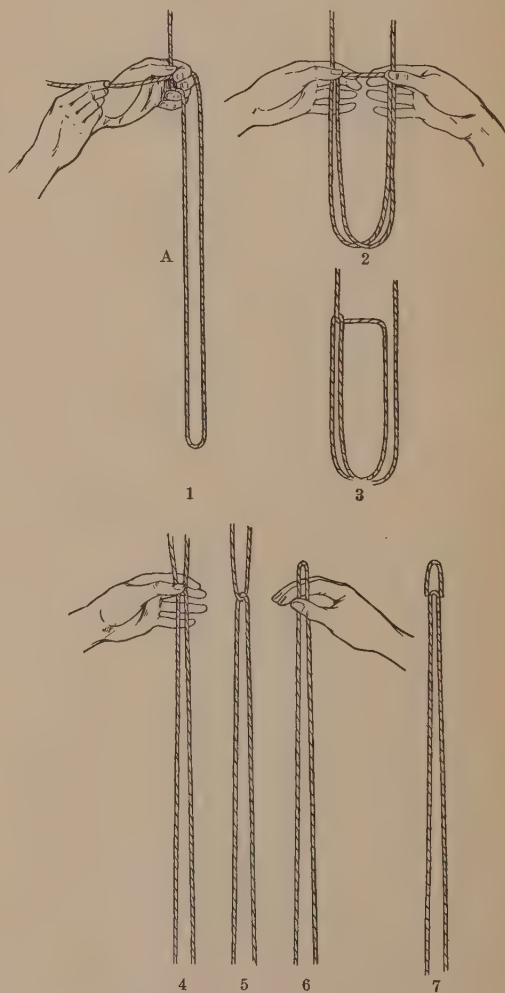
This calls all eyes to the box, and gives him an opportunity to drop the empty drawer into his lap or behind a book or other convenient object placed beforehand on the table. Then, blowing upon the box, and pronouncing some magical formula, he pushes open the box again, showing that it is still full of matches. This is done with the one hand only, the other falling carelessly on the matches already turned out on the table, and secretly getting possession of a score or so of them, which he holds against the palm by the pressure of the thumb. The second lot of matches is now shaken out upon the first, and again the box is closed. Once more the performer blows upon it, and, under cover of so doing, turns it upside down. When he again opens it, it is once more apparently full, the matches glued to the bottom of the drawer being now brought into view. Transferring it to the opposite hand, he gives it a shake, allowing the matches concealed in that hand to fall from it as if out of the box, then again turning it, so as to bring the empty side of the drawer uppermost.

"Now," he says, "you can all testify that these matches came out of this box. To show you that there is no deception, and that they have really multiplied, we will try how many we can put back

again." He fills the box, but there is still an equal number left over. These he presents to the company.

CUTTING THE MAGIC STRING

THIS is an old trick, but it is a very good one, and, improved to the form we are about to describe, it is very little known. It can be performed just as well by a girl as by a boy, and it has the great advantage of requiring no previous preparation. When we have once acquired the necessary skill, we can perform it at a moment's



THE TRICK OF THE MAGIC STRING.

notice, all that we need being a pair of scissors and a piece of string.

The string should be about four feet long. We begin by taking one end of it in each hand be-

tween finger and thumb, the rest of the string hanging down between them. But the end in the left hand is not held quite in the same way as the other, though no one not in the secret would notice any difference. If we look at picture 1 we shall see that the string passes out between the second and third fingers, and hangs down outside of the third and fourth ones.

Our next step is to bring that part of the string which is held in the right hand between the first and second fingers of the left, as shown in the picture, and draw it toward ourselves till half its length has passed through the fingers. Then with the right hand, still retaining the end we hold, we make a "grab" at the left-hand string at the point marked A, and bring it up so as to lie level between the hands, as shown in picture 2. To any one looking on, it seems as if you had merely gathered up the string in a double loop, but it is really as shown in picture 3.

Holding the string as above described, we ask some one to take a pair of scissors and cut it in halves, the portion between the hands appearing to be the middle, and he cuts at that point accordingly. When he has done so, we let go the string with the right hand, and let it hang down from the left, as shown in picture 4. Everybody imagines that it is fairly cut in half, but the real state of things is shown in picture 5.

Our next step is to transfer the string to the right hand, not disturbing its arrangement, but taking hold of it a little higher up, so that the upper ends, as well as the point where the two pieces of string cross each other, shall be hidden by the fingers. Asking some one to take hold of one of the long ends, we wind the rest of the string round our own left hand. This draws off the loose bit into the other hand, and when we again unwind the string it is found to be all in one piece, as at first. The little bit remains concealed in the right hand.

But we have not yet finished. Somebody—some uncomfortable person who knows, or thinks he knows, everything—may say, "Oh, yes; I know how *that's* done. The string was n't really cut in half. You only had a bit cut off one end." "Oh, you think so?" we retort. "Then I will do it over again, and this time you may measure the string before and afterward." If nobody makes such a remark, we volunteer of our own accord to do this. While the string is being measured, we secretly double the bit that remained in the right hand, with the "loop" end upward, keeping it concealed between the fingers and thumb. When the string is handed back after having been measured, we double this also in half, and, taking it by the middle between the right-hand

fingers and thumb, draw up for an inch or so what is apparently the loop thus formed, but is in reality the little loop made of the short bit. Picture 6 shows how the string now looks, and picture 7 the real state of things. We let some one cut through the loop, and wind the string round the left hand as before. It is again found restored, and when measured will, of course, be found to have lost none of its length.

This is not an easy trick to describe clearly in print, but if you follow the instructions with the string in your hands, and study the pictures, you will soon learn it. And it is worth learning, for it is a genuine sleight-of-hand trick, and such tricks are most mystifying.

SIMPLE TRICKS FOR ODD MOMENTS

THERE are many simple tricks performed with little or no apparatus that cause a great deal of amusement at any gathering of friends.

For instance, we announce that we can place a glass of water on the table, cover it with a hat, and then drink the water without removing the hat. This seems an impossible task, and every one is anxious to see the trick performed.

It is done in this way: We stand a glass of water on any ordinary table, borrow a hat, and place it over the glass. While doing this we talk and emphasize the wonder of the trick we propose to show our audience, and say that on no account must any one touch the hat.

Then we go under the table and make a pretense of drinking the water through the wooden table. Every one is, of course, skeptical, and after coming from under the table we ask one of the audience to remove the hat to see if the water has been drunk or not. As soon as this is done, we seize the glass and drink the water, and then announce to our surprised audience that we have done what we promised to do—namely, to drink the water without removing the hat, some one else having removed the hat for us!

Another simple trick is to take two cents from our pocket, and then ask if any one in the audience will lend us a cent. Of course, some one immediately does so, and we now have three cents. Placing the coins on the table, one after the other, we count them as we do so, saying:

"One, two, three—that makes four cents."

"No, three cents," says the one who lent the cent.

"One, two, three—that makes four cents," we repeat, as we count out the three cents again, and regard our friend with a surprised look.

Our friend insists once again that we have three only, and then we exclaim:

"Well, can I keep the cent if I am wrong?"

In nine cases out of ten the answer will undoubtedly be "Yes."

"Well, I *am* wrong, so I keep the cent," we reply, and our friend then realizes that he has been tricked, while the audience laughs heartily. We should practise this before trying it at a party, for the success of the trick depends upon there being no hesitation in the counting.

There is another simple trick that usually mystifies an audience and creates much interest. We undertake to pick a marked coin out of a hat without seeing it. First of all we borrow a hat, and then ask three or four members of the audience to put a cent each into the hat. We next cover this with a pocket-handkerchief, and talk for a minute or two to allow the coins to get cool.

Now we ask any member of the audience to take one of the coins from the hat and put a mark upon it, after which he is to return it to the hat and cover the whole with the handkerchief again.

Then comes the climax of the trick. Approaching the hat without looking at it, we talk of the wonders of magnetism, and, putting our hand under the handkerchief into the hat, extract the marked coin, to the astonishment of all beholders.

The explanation is as follows: In marking the coin, the member of the audience handled it for some few seconds, and the heat of his hand was communicated to it. When we feel the coins in the hat, the warmth of the one that has been handled is quite perceptible, and we are able to identify and to bring it triumphantly from the hat.

To be still more certain that the coin selected and marked shall be warm, we can ask the one who marked it to hand it round among the other members of the audience, so that they may all examine it thoroughly and be able to recognize it again when they see it. This adds to the importance of the trick and creates greater interest, besides insuring success.

THE CONJURER'S LITTLE JOKE

At the end of a series of tricks it is often a source of great amusement to entertain the audience with what school-boys call a "sell"—a practical joke in the disguise of a conjuring trick. The only apparatus needful is the pencil, and this you can manufacture for yourself. You have merely to change an ordinary pencil in such a way as to make it look like an extraordinary one. For instance, you may paint it in three colors—red, blue, and yellow, successive rings of each

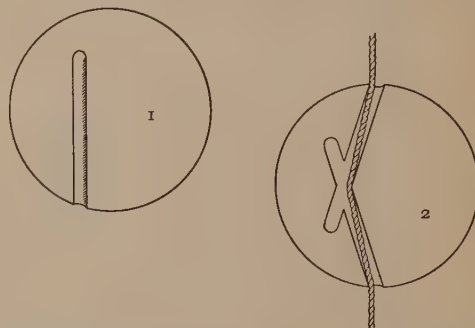
color; or, for lack of paint, colored paper may be used—anything, in fact, to give it an unusual appearance.

Having performed a few genuine tricks, you produce the pencil and a blank sheet of paper, inviting the company to examine them. "Now, ladies and gentlemen," you remark, "you notice, no doubt, that this is a rather peculiar-looking pencil. But its appearance is the least of its peculiarities. In point of fact, it is an electric pencil. At present, you see, it writes plain black like any other pencil." Here you make a few marks with it and proceed: "But if I electrify it a little, it will write red, blue, or yellow—in fact, any color, just as I please. What color will you have? Choose for yourselves." "Red," we will suppose, is the reply. You gravely breathe upon the pencil, rub it upon your coat-sleeve, and proceed to write the word "Red" in bold letters. "There it is, you see—red. If you had asked for blue or yellow, it would have been just the same." Which nobody can deny.

The success of the trick rests on the fact that the audience have been prepared, by seeing sundry surprising things, to expect something else equally surprising. If the trick were offered off-hand, without such preparation, some of the audience would probably see through the joke; but if it is led up to in a proper manner, they will hardly ever do so.

THE BALL THAT ANSWERS QUESTIONS

ONE of the most interesting toys is a ball that seems to count and answer questions. To people who do not know the secret of its manufacture it

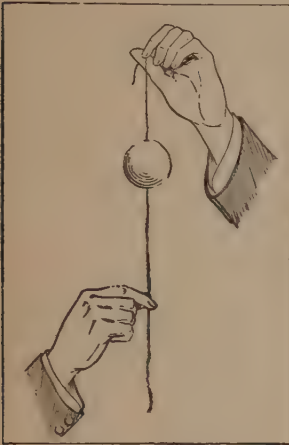


HOW TO MAKE THE HOLE THROUGH THE MAGIC BALL.

is very mysterious; and any boy can derive much amusement by making one, and showing it to his friends after he has practised with it a few times and become expert in its use.

Take a wooden ball about three inches in diameter, and mark upon the outside two points,

exactly opposite each other. In most wooden balls we find two center-points, that the wood-turner has used when making the ball. Then we use a gimlet, and make a hole in the ball, but *not* in a straight line toward the other point. The



3. HOLDING THE BALL.

first illustration (1) shows how the hole is made; it is not through the center of the ball, but to one side. The hole is not made to go right through the ball, but it must go more than halfway.

Now we bore another hole from the opposite point. This is the only difficult part, for the second slanting hole must be made so that it goes right into the first hole, and the

result is that we have a continuous hole right through the ball, but not in a straight line. The

next picture (2) shows how the hole should be made, going through the ball, but not in a straight line.

Now we put a string through the hole from side to side, and after doing so we had better put a button on each end of the string, to prevent it from slipping out of the hole. Now, if we hold up the ball as the boy in the next picture (3) is doing, pulling the string tightly as we do so, we find that the ball remains fast at any part of the string we like. Let the string loose just a little, and the ball begins to slip down. Again tighten the string and again the ball rests.

Now we can ask the ball questions. Hold the string tightly with the ball at top of it. "Ball, how many do two and three make?" we ask; and, for reply, the ball takes five short steps down the string. Of course we are making it do so, by making it tight and loose as we wish. Then we say: "Ball, I am going to ask you some questions. If you mean yes, move once; if you mean no, move twice." We can ask any questions we like, and the ball can always answer them if we are allowed to hold it up by the string. A little practice will enable us to move the ball without any one detecting how we do it.

TRUZZLES

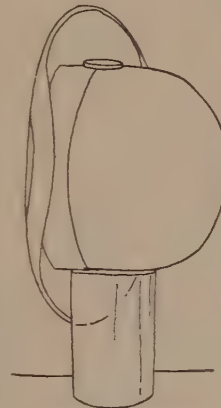
BY NORMAN D. GRAY

TRICKS and puzzles are always in order during winter's indoor hours, but it is hard to find anything new. Here are a few little feats that may have the charm of novelty for many boys and girls. The experiments are neither tricks nor puzzles in the full sense, though they combine something of each. Our old friend Lewis Carroll would no doubt have arrived at "truzzles" through trying to say both words at once. One might do worse than to follow his example. All may be done with cents, or, if you will persist in so calling them, "pennies."

"In the first experiment on our program, ladies and gentlemen, we employ a copper cent, an ordinary glass tumbler, and a very ordinary derby hat." The poor quality of the last-named article must be insisted upon, as it is to receive hard usage. Place the hat over the tumbler, and the cent upon the hat, as in the picture. The trick, or the puzzle, or the truzzle now is to strike the hat from under the cent with a smart blow of the hand, allowing the coin to drop into the tum-

bler. It seems to be easy, but skip the next paragraph until you have tried it.

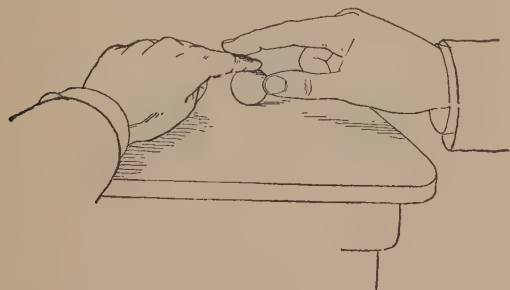
To do this successfully, which with practice may be done before an audience without discovery, place the hat between yourself and the company, with the crown away from you. Make several feints as though about to strike the outside of the brim on your right (if you are right-handed); but when the final quick blow is delivered, the inside of the brim on your left is the place to be hit. If this little trick is neatly performed, the audience will believe the outside of the hat to have been struck, and the copper will fall nicely into the tumbler. The spectator may puz-



THE COIN AND TUMBLER.

zle his brain for some time before he can solve and successfully perform this truzzle.

A second truzzle, very mysterious, is the magic spinning of a coin without evident impact. This sounds impossible, and really appears to be so



THE SPINNER.

when seen. The coin is held on edge by the first finger of the left hand, in the ordinary position for a snap spin. The right forefinger is now laid across the left, and passed repeatedly from knuckle to tip—"to produce magnetism," you may say to the onlookers,—and finally swept quickly off the end of the finger, apparently without touching the coin. The latter, however, bounds merrily to the middle of the table, and there spins contentedly, as if of its own accord.

The accompanying illustration will make the trick of this truzzle clear. When the final stroke is given with the right finger, the thumb assumes the position shown, and is allowed to strike the edge of the coin, unseen by the spectators, and thus set it spinning.

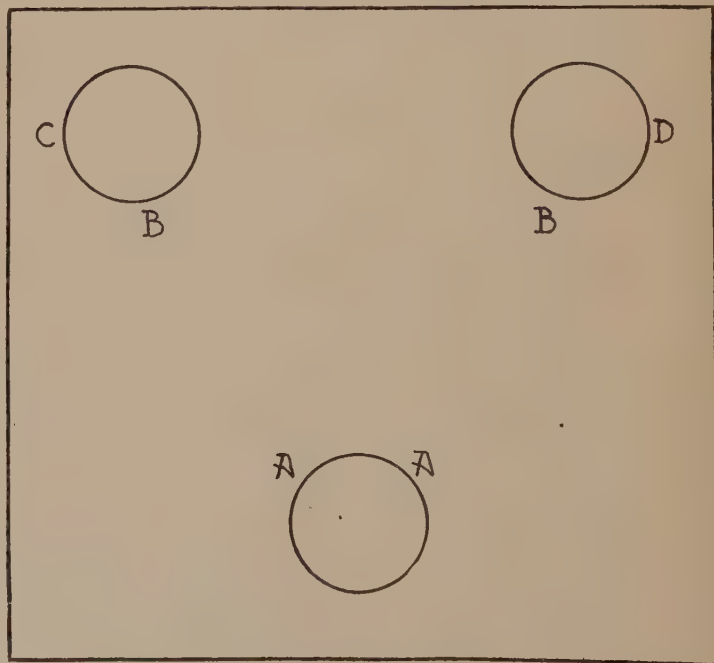
While dealing with single coins, there is another clever puzzle which must be included, even at the risk of straining a point to raise it to the dignity of a truzzle—though, on second thought, there is something of the trick about it, after all. Cut a circular hole, about nine sixteenths of an inch in diameter, in a sheet of writing-paper. Through this opening, without tearing or cutting the paper in any way, a cent may be readily passed (when one knows how), although the diameter of the coin is considerably greater than that of the hole.

Place the cent over the hole, and fold the paper without creasing, so that the coin is in a kind of

pocket, and partly projecting edgewise through the opening. Grasp the paper firmly, so that it cannot slip, and bend it slowly along the edges of the coin, though not forcibly enough to tear the paper, lengthening the diameter of the hole in the direction of the fold until it will allow the coin to drop quietly through upon the table. This result is surprising even to the operator, and furnishes a very interesting question for discussion. How is it possible for a solid coin to pass through an opening very much smaller than itself, and that without actually enlarging the aperture one iota? Who can answer it?

But here is something over which you need not bother your brains to such an extent. What would you think of being asked to drive a needle completely through a copper coin? Impossible? Well, it does seem so, and yet it may be done without hurting the needle in the least.

As for the method: First you select a cork a trifle shorter than the needle you mean to use. Push the needle through this cork until its point just appears at the other end, and break off the needle below the eye flush with the cork; then, holding "the business end" of the cork firmly against the coin, which must rest upon or against



THE COINS IN A TRIANGLE.

a rigid surface, strike it a fairly hard blow with a hammer. Examine the result, and profit by what you see.

Having now tested the brain and hand, sup-

pose an eye-test be attempted. Here is a form of optical delusion which shows how very difficult it is to measure distances accurately with the eye when there is the slightest thing to confuse the judgment. The following test is neither a trick nor a puzzle, and so naturally must fall in the third division, and take rank under the head of the present article. Place two coppers, a few inches apart, on a clean sheet of paper. The truzzle is to place a third copper below these, as in the diagram (judging entirely by the eye), so that the inside measurement, AB, shall be exactly equal to the outside measurement, CD. Draw a circle where the coin has rested, and mark it with your initials. Others may then try, and it will be interesting to compare results.

You will notice that the coin is invariably placed much nearer to the others than it should be, unless, of course, the tendency to error is known beforehand. One may attain some accuracy in the following way: imagine the coin resting on the paper so that the inside distances are equal, and then judge the width of two coins from the farther edge of the one you have imagined to be placed. The point thus obtained, provided that your eye is "good," will be found to coincide very nearly with the true one.

Put two coins side by side upon the table so that they touch each other, and take a third one in hand. The first you may touch, but not move; the second you may move but not touch; the third you may both touch and move. The object is to place the third coin between the other two.

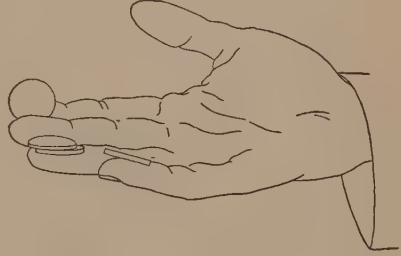
Place your finger upon the first coin, and hold it tightly. Snap the third against this one, when the second, which was to be moved but not touched, will bound away far enough to leave room between itself and number one, which was to be touched but not moved, for coin number three.

Before leaving the subject of truzzles with coins, there should be mentioned three feats of skill in manipulation which furnish opportunity for practice in spare time. The first is an old trick, or knack, but must be new to some of you. Bend the arm, with the hand palm upward, over the shoulder until the forearm is horizontal. Place a coin upon the elbow and make a quick snatch at it with the same hand. It is a surprise to find it securely held in the fist.

With practice, a pile of coins may be caught in this way as easily as one, the whole secret being to treat them exactly as though they rested in the air, and to give no thought whatever to the arm on which they rest.

The second truzzle of pure skill is more difficult to attain than the first, and, therefore, one

experiences a proportionately greater satisfaction when able to perform it neatly. Place four coins on the back of the hand, letting the last rest on the wrist. Now toss them upward, being careful that they preserve their relative positions, and, with the same hand, catch them, in quick succession, before they can fall to the floor.



TRAVELING COINS. FIRST MOVEMENT.

This is by no means easy to accomplish, and had best be practised first with two coins, and then with three, before attempting four. The secret of the knack is in the toss and *start*. Give them a steady, sweeping throw, not a jerky one, and (here is the important point) start to catch them—securing at least the first coin—before they begin to fall. Keep cool, have patience, and success will follow.

And now for the last and best of all—the finger truzzle with four "pennies." It had nearly been called "the four-cent finger truzzle," but there is a certain suggestion of cheapness about that phrase entirely unworthy of the feat. With the palm of the hand up, place a cent upon the tip of each of the four fingers, and without the use of the thumb, or of the other hand, without any aid whatever other than the fingers, pile all four coins upon the tip of the third finger of the same hand. It would be hard to find a more perfect example of the true truzzle. First, one must



TRAVELING COINS. LAST MOVEMENT.

discover how to do it (for it can probably be done in only one way), and, secondly, one must acquire the necessary deftness or skill for its accomplishment.

It is a pity if the illustrations have silently given you too broad a hint before you have had a chance to try this truzzle for yourselves. However, knowledge of the method is but half the battle won. The pictures will explain themselves. The first move is from the second finger to the third, the coin being slipped over with the assistance of the forefinger. The coin from the first finger must now be tilted on to the second (as in Fig. 1), to be then slipped to the third finger in the same way that coin number one was moved. The third coin is the most difficult to maneuver. Tilt it from the little finger to the forefinger (as in Fig. 2), after which it follows the course of

coin number two. In general, it will be found conducive to success to hold the hand low, keeping the forearm nearly horizontal, and to have no support for the elbow. Practice will enable one to perform this feat with much apparent ease and dexterity. It is very effective, and more than pays a bright boy or girl for the trouble of learning it.

With this the coin truzzles shall be brought to a close. These will doubtless suggest others to the bright members of the party, and so the hours will pass by like the silent ghost of an express train, as hours have a knack of doing when one is busily employed.

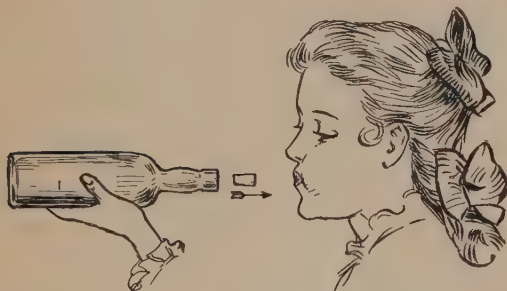
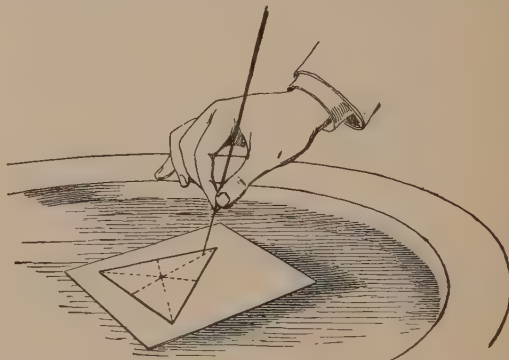
TRICKS THAT ANY ONE MAY TRY

BY BORIS GLAVE

THE OBSTINATE CORK

WHEN I was a boy we had a song about "Aunt Jemima's Plaster," the peculiarity of which was that "the more you tried to get it off, the more it stuck the faster." Here we have a picture of an experiment with an obstinate cork that flies in the face of any one who tries to compel it to go into the neck of a bottle. The more you try to blow it in, the more it leaves the bottle. You can try this with any large bottle and a cork small enough to fit very loosely in its neck. Holding the bottle so that it points directly at your mouth, and placing the cork in the neck, the harder you blow on the cork for the purpose of driving it

a piece of thick paper a triangle—whether the sides are equal or not makes no difference. Lay



into the bottle, the more forcibly will the cork rush from its place in the neck. Instead of a cork, the experiment may be successfully tried with a small ball of pith, or with one of paper.

THE MAGIC TRIANGLE

A VERY interesting experiment may be performed as follows: with a *wet* lead-pencil point draw on

it on the surface of a basin of water with the drawing up, and very carefully fill the space inside the dampened lines with water, so that there will be a triangular basin of water on the swimming sheet of paper. (The water will not extend beyond the wet lines of the drawing.) Now, taking a pin or a needle, or any thin, smooth, sharp-pointed instrument, dip its point into this triangular basin, anywhere but at its center of area—say, very nearly at one of the angles. Be careful not to touch the paper and so prevent its free motion in any direction, and you will find that no matter where the point is placed, the paper will move on the water until the center of area comes under the point. This center of area may be indicated before placing the paper on the water by drawing lines from any two angles to the centers of the opposite sides; where the two lines cross will be the desired place.

If a square be drawn instead of a triangle, and similarly treated, it will move until the intersection of its diagonals comes under the pin-point; and no matter what figure be drawn, it will move along the water so as to bring its center of area directly under the point.

THE POWER OF A BREATH

IN order to show what force, not figuratively, but actually, a breath has, take a good, stout, tight paper bag, and laying it on the edge of a table so that its mouth projects, stand a heavy book on end on the bag, and across this book lay another, also of considerable weight. By blowing



in the bag, keeping the mouth tight in the bag so that no air can escape, the upright book will be tilted and raised and the structure overthrown. It would, of course, be impossible to blow the book over without the aid of the bag.

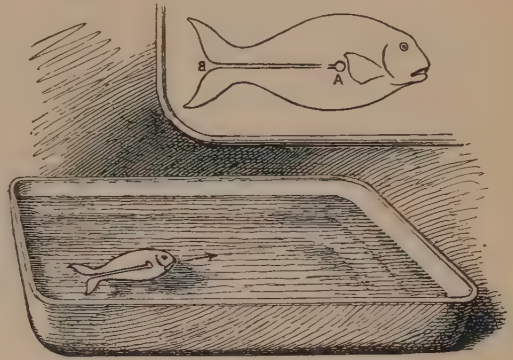
THE PAPER FISH

CUT a fish out of stout writing-paper, and in the center cut a round hole, as shown at A in the figure; then from this cut out a narrow strip reaching to the tail.

Placing this paper fish in any long vessel full of water, it will, when you are ready for it to do so, slowly move head first along the surface of the water without your touching it. (Care must be taken to lay it gently on the water, so as not to wet the upper surface of the paper.) The fish, of course, lies *flat* on the water.

The secret lies, not in blowing the fish along, as some promptly guess, but in placing in the

opening A a large drop of oil. This tries to expand and extend over the surface of the water; the paper is not porous enough to absorb it



promptly, so the oil seeks the path of least resistance. In this case this is found to be by passing out of the channel which leads from the hole A to B; and in issuing from this channel it will push the fish forward.

A JUMPING TRICK

LAY ten toothpicks in a row at equal distances. Move them by "jumping," as in checkers, so that two shall be "jumped" each time, and at last five pairs remain.

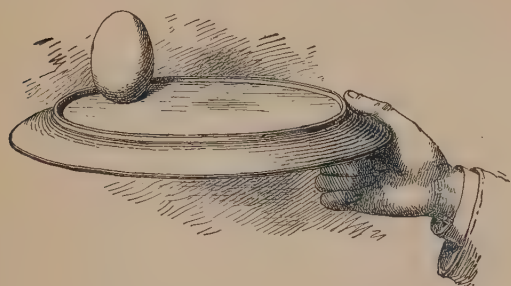


SOLUTION: Lay 7 on 10, 4 on 8, 6 on 2, 1 on 3, 9 on 5.

THE DANCING EGG

To make an egg dance on the bottom of a plate, first boil it hard; then set it on its large end in the center of the plate, and, holding the latter horizontal, give it a rotation in a horizontal plane; the egg will keep spinning like a top. With practice, the egg may be made to assume the vertical position after being laid on its side. To facilitate prompt obedience on the part of the egg, hold it vertical, with the large end downward, while it is being boiled. To make the trick still more easy to perform, lay the plate on a table with the edge projecting beyond that of the

table, and then start the egg spinning by use of the thumb and fingers. The projecting position



of the plate will enable you to grasp this latter quickly with the right hand, and then all that you will have to do will be to keep the egg spinning by giving the plate its rotating motion.

TO BLOW A COIN OUT OF A GLASS

It would seem, I admit, a bold statement to say that you could put a penny (or rather a "cent" in America) in the bottom of a wine-glass, cover it up with a dollar, and then, without touching either coin, blow the cent out of the glass without removing the dollar from the latter. Yet it can be done—if you know how.* The cent is laid in

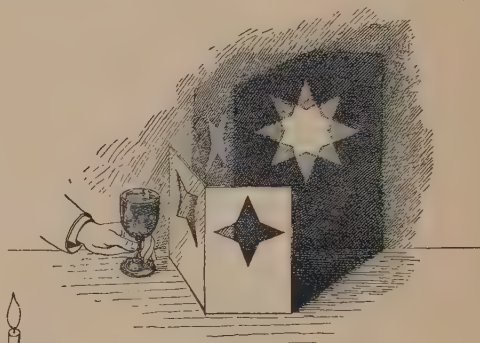


the bottom of the glass "sure enough," as they say down South; then the dollar, which is very much larger, is laid in so that it lies in a horizontal plane at some little distance above the cent. Now to get the cent past the dollar and out of the glass with the breath alone, blow sharply downward on that side of the upper face of the dollar which lies next to you. This will cause the coin to tilt as though on an axis; and

the cent will be blown, by the current of air reflected from the bottom of the glass, past the dollar and up out of the glass.

THE THREE-COLORED STAR

To produce this pleasing and remarkable effect, take a square piece of cardboard (say eight inches on a side) and fold it down the center. In one of the divisions draw and cut out a four-pointed star with the arms vertical and horizontal; lay the piece cut out from here on the other division of the cardboard, but with the arms



diagonal, and having marked its outline exactly, cut out that star. Stand the card on end, as shown in the figure, on a table which is pushed close to a white wall, or on which is stood a white screen. Place two lighted candles on the table in such positions that the stars cast by the openings in the card fall together on the wall, making an eight-pointed star. Now, holding a piece of colored glass, paper, or gelatin, or a glass of colored liquid, between one of the candles and its corresponding star, the eight-pointed light star on the wall will be three-colored, the colors varying with the color used for the screen. Where a red screen is used to color the light falling on one four-pointed star, the eight-pointed star will be red, green, and white. If a yellow screen be used to color the light, the eight-pointed star will be yellow, purple, and white, etc. This is a good exercise in "complementary colors."

QUEER ERRORS OF THE EYE

BY ARCHIBALD HOBSON

WE all cherish the notion that our eyes can make no mistake. We depend on our sight more than on any of our other senses. Civilization has dulled for us our smell and hearing, and our taste and touch play but small parts in our life. The average person does not pride himself on his keenness of smell, hearing, touch, or taste, but he would be loath to admit that he could not "believe his own eyes." Notwithstanding, there are many cases, as we shall see, in which the eye shows itself to be but a poor judge of facts, incapable of telling to the mind a truthful story of what it sees.

In Fig. 1 the light vertical line EF looks longer than the heavy horizontal line GH, though both are of the same length. This illustrates the principle that a narrow object looks longer than a wide one of the same length, and that a vertical line looks longer than a horizontal one of the same length. Stout people look short because our eyes naturally discount their height, while thin people appear taller than they really are. Young ladies with an ambition to look stately cultivate meager, clinging effects in dress; short women select patterns having perpendicular stripes, and exceptionally tall women avoid such. Paper-hangers who understand their trade put a narrow border round the top of a low room. Large patterns in wall-paper or carpets make a room appear small and ill-proportioned.

In Fig. 2 the segment J appears easily larger than the segment I, but in reality they are identical in shape and extent, and if you were to cut out the two one would exactly cover the other.

The sides of the ladder shown in Fig. 3 appear to be closer together at L than they are at K, but they are really parallel. The effect is due to the oblique cross-hatch or section lines. Draftsmen are frequently embarrassed by illusions of this kind, which often give drawings a distorted appearance notwithstanding their technical accuracy.

If you were told that the lines MN and OP in Fig. 4 were straight and parallel you could hardly accept the statement; yet you can easily see that this is so by looking along the two lines from either end, or by measuring.

The black spots in Fig. 5 and the white spots in Fig. 6 are of the same size, but the white spots look the larger. This is due to the phenomenon of irradiation, which always makes a bright object against a dark background appear larger than it really is, owing, as Humboldt found, to

the imperfect focusing of the object on the retina of the eye in such cases. By reason of irradiation the stars appear to our eyes larger than they otherwise would; and, to descend to the everyday, women well understand that in dress-goods light "polka-dots" on a dark ground look larger than dark ones on a light ground. Certain microscopic animals have markings which for a long time were taken to be hexagonal spots, giving a honeycomb appearance; but more powerful microscopes have shown these spots to be round. By partly closing the eyes and looking at Figs. 5 and 6 the spots will assume the hexagonal shape, thus illustrating this puzzling illusion.

Fig. 7 represents an adaptation of the famous illusion discovered by Professor Silvanus P. Thomson. By giving the page a slightly twirling motion similar to that used in rinsing out a dish, the cog-wheel on the left is made apparently to revolve slowly, while the wheel on the right turns rapidly in the opposite direction. This illusion is one of the most interesting and remarkable known. A variation of it is shown in Fig. 8. When this design is twirled as before, the six wheels appear to revolve rapidly, intermeshing with one another, while the central cog-wheel revolves very deliberately in the other direction, giving the appearance of a rather complicated piece of machinery in motion.

Printed letters show how usage has come to recognize certain peculiarities of vision, being understood. The letter S, the figure 8, and the letter B appear to be symmetrical or practical; but if you turn the page upside down you will be very much larger than their upper sign-painters and understand this illusion, derstand this illusion,

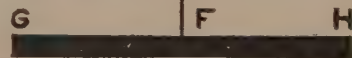


FIG. 1.

all such letters and figures symmetrical by measurements, with the result that their work will appear distorted and inartistic when finished. The cross-line in the letter A should appear about midway of the height of the letter, but in order to produce this effect it must be made considerably below that point. By a gradual process of

evolution the letters and figures we use have grown into shapes that are satisfying to the eye, though they are not symmetrical.

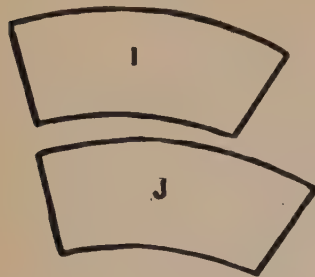


FIG. 2.

ures, and then gradually bring your face closer and closer to the page, keeping both eyes open. The result will probably be that the reckless Chinaman and the timid young woman will have a collision.

In Fig. 11 we see a curious effect of the distortion of perspective. The figure of the man looking over the fence at the ball-game appears to be actually taller than that of the small boy who is peeping through the knot-hole, but in reality it is a little shorter. The illusion is due to the fact that we judge of size always by comparison. The eye sees the figure of the boy larger



FIG. 3.

than that of the man, as it really is; but the man being represented farther away, the mind draws the conclusion that he must be the taller, for our daily experience is that distant objects must be larger than near ones having the same angle of extent.

We see everything, in short, by the light of experience alone. New-born babies, while they have eyes, see not. The eye is a camera pure and simple, and, until its impressions can be developed in the consciousness, what it sees means nothing. The baby first learns to distinguish



FIG. 4.

light from darkness; then it learns to recognize its mother, then its father; then it learns, per-

haps, to distinguish some bright color, red it may be; then it learns to discriminate between near

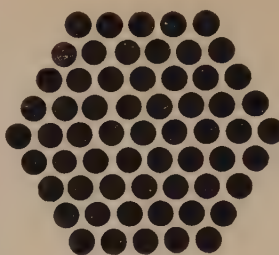


FIG. 5.

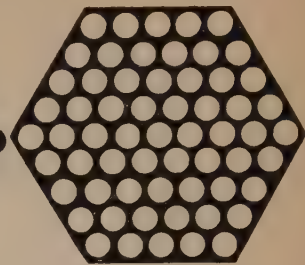


FIG. 6.

and far objects. It looks at the nearest house down the street and takes it to be of about the size of its Noah's ark, for so it appears to be. Later it goes to that house and discovers that it



FIG. 7.

is as big as its own house, which now, at a distance, in turn looks smaller. Gradually it makes its way from the known to the unknown, using its own experiences as stepping-stones. The eye



FIG. 8.

knows no such thing as size or distance in the abstract and apart from reasoning, but knowing

one by experience, it can make a close estimate of the other.

The average woman cannot judge how much a foot is within several inches, but she can estimate a yard very closely, while with the average man the case is reversed. If some one asked



FIG. 9.

you which was the longer, a horse's head from the tip of his ears to the end of his nose, or an ordinary flour-barrel, you would naturally say the barrel, though the horse's head is the longer. The eye is very easily deceived if it is called on to pass judgment on something that has not been brought home to it by experience. The land-lubber at sea greatly underestimates the distance of passing ships, having no familiar landmarks with which to make comparisons. Truthful men under oath in court often disagree widely as to observed facts, and no doubt with perfect honesty. We will not distrust our eyes, though no doubt they deceive us oftener than we realize.

The eye constantly overestimates an acute angle and underestimates an obtuse one. It is this principle on which the illusions shown in Figs. 3 and 4 depend. A right angle should be much easier to judge, but unless the eye is trained it will go astray considerably. Even a carpenter, who constantly deals with right angles, will not trust himself to saw a board off without a square if he has to make an accurate fit. Beginners in drawing generally find themselves making all vertical lines lean slightly to the right. The buildings in their sketches topple quite uniformly in that direction, as shown in Fig. 10. The error becomes

more evident when the drawing is turned on its side. And still a picture made with a ruler and T-square would lack the artistic quality. An artist would never use a ruler to draw a line by, for he understands that the eye demands something more than mere methodical accuracy of line and angle.

There should be an element of illusion in every picture, and the true artist is one who knows how to make allowance for this. So also in architecture. Measurements of the finest buildings left us by the ancients show us conclusively that the skilful architects of those old times understood perfectly about the illusive effects of lines on the eye, for they so designed their buildings as to counteract such defects of vision. The walls, instead of being vertical, lean in; tall windows are wider at the top than at the bottom; columns swell in the middle instead of being straight; the top lines of the buildings, instead of being strictly horizontal, are considerably higher in the middle, and so on. Without doubt



FIG. 10.



FIG. 11.

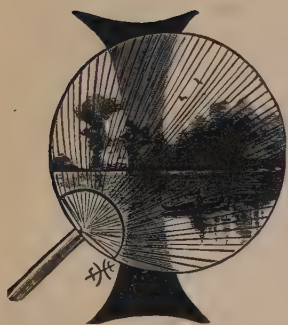
much of the beauty of these classic buildings was due to the recognition of such principles in their construction. Modern architects generally ignore everything of this kind and build strictly by the square, level, and plumb-line. There are fine buildings in every city that have been made to suffer in this way, for, though really well built,

their walls appear to lean outward, or their cornices to sag in the middle, and so forth.

These various instances point the moral that our eyes do not by any means always see things as they are, and that if we are not taught how to accept their reports with a "grain of salt" we shall occasionally be misled more or less.

SEEING AND BELIEVING

BY HAROLD WILSON, M. D.



It is an old and a wise saying that "seeing is believing," yet everybody knows that very often what we see, and therefore believe, proves to be not really true at all. As we grow older, finding that our eyes have so frequently deceived us, we are often not

satisfied with the evidence they give us until we have verified it by touch or smell or hearing or taste, or by looking at some doubtful thing from different points of view, or under a different lighting.

We are not willing to believe that a conjurer actually draws rabbits from a man's ear or coins from the tip of his nose just because our eyes tell us such tales. Sometimes our deceptions are so lasting that things must be made wrong in order to look right, which seems rather contradictory. If we look at the letter S or the figure 8 as carefully as we can, the upper and lower halves seem to be almost exactly the same size. If we turn them upside down, thus, S, 8, the difference in the size of the loops is quite astonishing, and we wonder how we could have been so mistaken; yet perhaps the truth is that the loops are neither so different nor so much alike as they seem to be, as we see when we look at them turned upon their sides, thus, S, 8.

The eye is such a delicate bit of machinery, it has so many parts, and so many different kinds of work to do, and such long hours of labor, that it is not surprising, after all, if in the capacity of receiving-office for so many millions of light-waves every minute, it should occasionally send wrong messages to the central station in the

brain. Nor is it to be wondered at if the mind itself, having so many other things to attend to at the same time, sometimes fails to understand what certain messages from the eye may mean. These mistakes on the part of the mind in interpreting the communications which the eye sends to it, are called *illusions of sight*.

Moreover, in the eye itself certain things may go on which give us wrong sensations, which, although not truly illusions, are very much like them. Thus, when we suddenly strike our heads or faces against something in the dark, we see "stars," or bright sparks, which we know are not real lights, though they are quite as bright and sparkling as if they were. When we close one eye and look straight ahead at some word or letter in the middle of this page, for example, we seem to see not only the thing we are looking at, but everything else immediately about it and for a long way on each side. But the truth is, there is a large round spot, somewhere near the point at which we are looking, in which we see nothing. Curiously enough, the existence of this blind spot was not discovered by accident, and nobody ever suspected it until Mariotte reasoned from the construction of the eyeball that it must

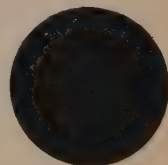


FIG. 1. THE VANISHING DISK.

exist, and proceeded to find it. Now we can all find it very easily. If you will hold Fig. 1 straight in front of the right eye, and about ten and a half inches away from it, the left eye being kept closed, then look sharply at the center of the little cross, everything being properly adjusted, the round black spot will disappear from view.

Some of our most delightful sensations are those of color. Nature has given us a great profusion of them, but the eye is not satisfied with what it gets legitimately, as it were, but creates for itself a lot of imaginary colors, which are often very hard to distinguish from the real ones which the light makes. If we take a sheet of gray or white paper and place upon it a small piece of orange-red paper, look intently at the red paper for a few seconds and then suddenly take it away, we will see a patch of a light-green color, which moves about as we move our eyes, and soon fades away. A bit of yellow paper gives us a blue patch, green a violet red, and with a package of kindergarten color-papers to experiment with, the reader will find that each one has its own unchanging and especial successor when tried in the same fashion. These after-colors are the creations of our eyes, and are not really where they seem to be. They are quite as unreal as are other sorts of ghosts. With a candle or lamp, a few pieces of colored glass, and a lead pencil, we can display some other curious fancies of the eyes by making what are called colored shadows. Fig. 2 shows how it is done. Using red glass, the shadow of the pencil upon the wall (a piece of white paper is better) looks blue-green; with blue glass, yellow; with green glass, rose; and so on. It is hard to convince ourselves that the shadow is not actually of the color it seems to be, and if I did not tell you that it was an illusion, you might never discover the fact.

When we come to study the shapes and sizes of things, we find that the eyes are often greatly deceived. We all know how large the full moon looks when it has just risen, and how much smaller it appears when it rides higher in the sky; and those of you who have ever looked at it through a telescope or a pair of opera-glasses know that although it is then magnified, it actually looks smaller than with the naked eye. Those who know tell us that the big moon we see at the horizon is an illusion, and that while it actually is magnified by refraction, it looks much larger because we see it a long way off, through the trees, or over houses, or down the street, and

comparing it with those objects of which we know the size, fancy it must be very large because it is so far away; and that when up in the sky, or when seen through an opera-glass, it



FIG. 2. THE COLORED SHADOWS.

seems nearer, and therefore it appears to be much smaller.

In Fig. 3, the row of dots between *a* and *b* makes that distance seem greater than the distance between *b* and *c*, although upon measurement you will find it to be just equal. Fig. 4 does not look exactly square: the horizontal lines make it seem too tall. The artist was instructed to make the horizontal lines in Figs. 5 and 6 parallel to each other, and no doubt he has done so, although those in Fig. 5 seem very far from it, and it is perfectly plain to the eye that the upper ones in Fig. 6 separate more at the middle and that the lower ones come closer together there than at the ends; and if the top of the page

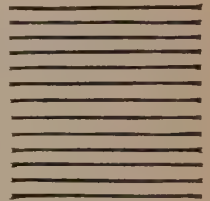


FIG. 4.

is tipped away from you so that you look obliquely down at it, these appearances are all the more striking. Yet if we turn the page about and look at the drawings from the side, we see at once that the artist has done his work truly, and that it is our eyes that have been at fault. So, in Fig. 7, the circle seems to dip in or flatten at the corners of the square, yet it is positively a true and uniform curve. In Fig. 8 the line running upward on the right-hand side of the black rectangle is the direct continuation of one of the two lower lines on the left. Everybody says that it is with the upper one of these lines; and as we examine it carefully, running the eye back and forth so as to be sure, this certainly

seems to be true. But hold the figure so as to look along the line as a carpenter looks along the edge of a board, and it is surprising to see how much we have been mistaken.

If I were to ask what Fig. 11 represented, most persons would say that it was a picture of a transparent cube of which three faces were visible,—the one toward you, the upper, and the left-hand one,—as is shown in Fig. 10. Some other person looking on might say, however, that it was a cube showing the *lower* and the *right-hand* faces, as shown in Fig. 9; and upon looking at it again, sure enough, this seems to be so; and yet, while we still look at it, it suddenly changes, and once more looks like Fig. 10. With a little practice, we discover that we can make it look either way at pleasure, though it has an uncomfortable fashion of turning about of its own ac-

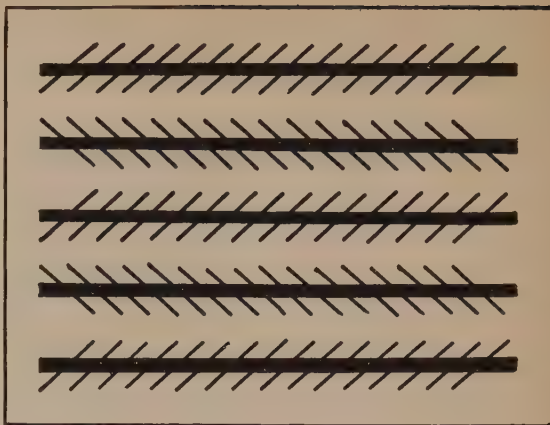


FIG. 5.



FIG. 6.

cord. Generally we can see it like Fig. 10 more easily, perhaps because that is the way most real cubes appear as we look at them usually from above. So Fig. 12 we can see either as a flight

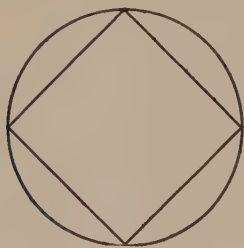


FIG. 7.

of steps leading up to the left, or as an overhanging or upside-down stairway which we could climb only by standing upon our heads. It is a

little hard to see these two stairways, and you may succeed better by turning the page around while looking at the drawing. It is easy, sometimes, to see objects that do not exist: thus, in Fig. 13, if the page is tipped a little and held so that the right eye looks along the line *a b*, and the left along the line *c d*, both eyes being open and looking at the point where the two lines cross, a third line is seen standing right up from the paper like a little rod or pin. Fig. 14, when

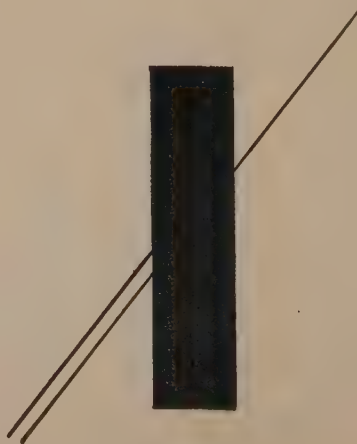


FIG. 8.

looked at with one eye from a point where it can look along all of the lines without moving the head,—that is, at a point where all the lines

them from very early times. Long years ago the Greek architects took advantage of these illusions to improve the appearance of the temples;

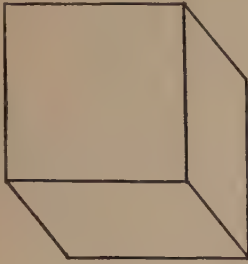


FIG. 9.

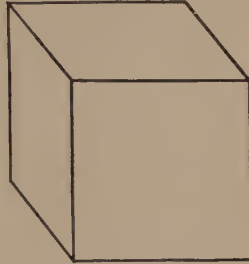


FIG. 10.

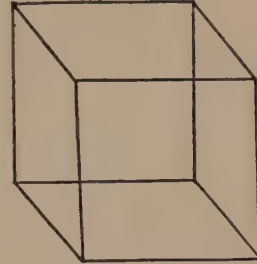


FIG. 11.

would meet if they were drawn long enough,—shows a lot of black pins standing upright as if stuck into the page.

In the picture at the end of this article, it will be found interesting to let the spectators guess which of the stones in the Magic Bridge is longest, and also to estimate the precise difference in length between the upper and lower pair. After

and it has lately been found that the cathedral builders of the Middle Ages also so arranged their lines and curves as to deceive the eye. Figs. 15 and 16 show how two lines of the

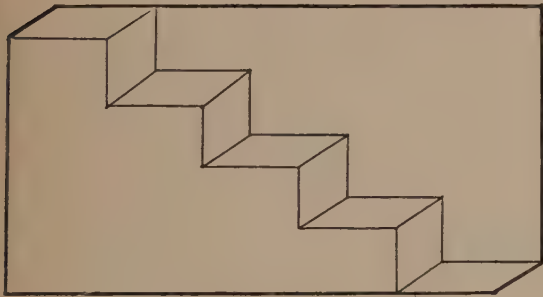


FIG. 12.



FIG. 13.

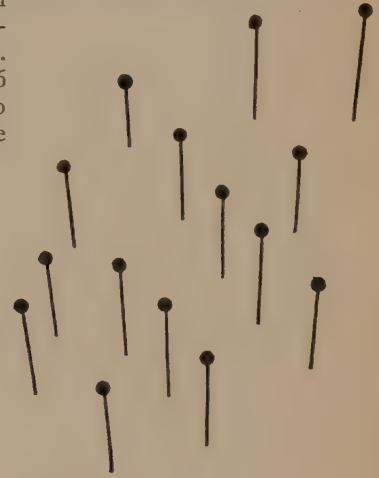


FIG. 14.

the guesses have been made, measure them; it will be instructive.

Now, we all want to know, of course, how these curious illusions come about, and whether

same length may be by branching lines made to look quite unequal; but it is a great deal easier to see that they are illusions than to explain why we are deceived in them. Even the wise men

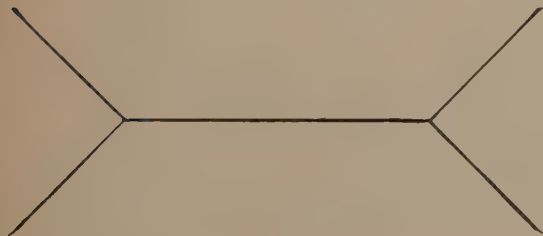


FIG. 15.

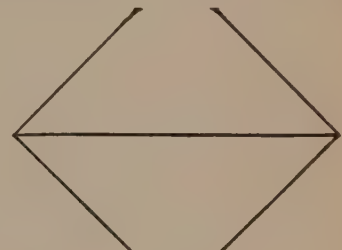


FIG. 16.

there are others than those we have just seen. Yes, there are many others, and men have known

who have studied them do not always agree in their explanations. And then, to understand

these explanations, we have to know a great many things that are not so interesting. Besides, what we need most of all to know about them is the fact that they exist, and that often "things are not what they seem," and that seeing ought not always to be believing. Our eyes must be trained to beware of tricks that may be played upon them, and where our eyes deceive, our brains must help us to find out the truth, even in the midst of apparent error.

WHY THE STARS DON'T TWINKLE

EVERY cloudless night the eyes make a mistake that we can easily discover, but which we are totally unable to remedy.

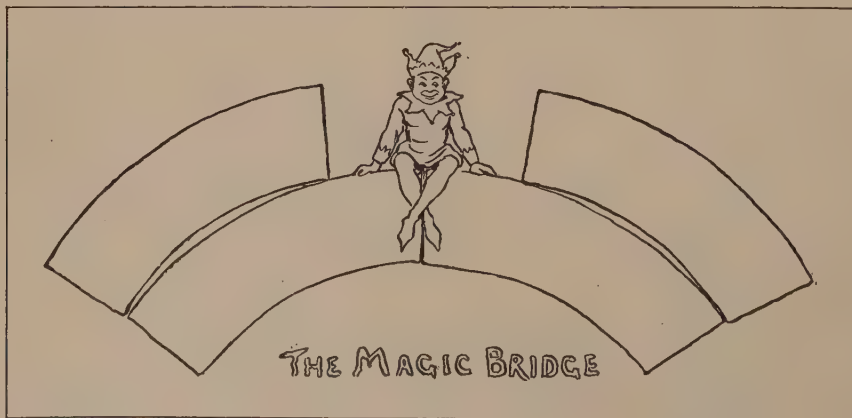
Of course you have looked up to the sky thousands of times and seen the stars twinkling. Not only that, but if the night is clear you can see they are stellate, or star-shaped, like the starfish which is named after them. You can see both of these things, and yet the strange fact is that neither of them is true!

The stars do not twinkle at all, and they are not stellate. The twinkling is the result of the intervening atmosphere, and not the fault of our eyes; but the second error can be easily brought home to our untrustworthy organs of vision by the following experiment.

Take a piece of tinfoil and prick a small hole with the point of a pin. Now when it is dark

put a candle behind the tinfoil in such a way that the light comes through the tiny hole. Hold the tinfoil about ten inches from your face, and the hole will appear irregular. If you bring it nearer, it will lose even the least resemblance to a hole and appear as a star! Of course you know perfectly well that it is round, but your eyes have deceived you once more in the same way that they deceive you every starlight night. This deception, or to put it charitably, this mistake of the eyes, is given the very high-sounding name of "irregular astigmatism," but for all that it is an illusion pure and simple.

Like many well-trained servants, the eyes are quite at a loss if anything contrary to the usual routine is presented to them. They know perfectly well the laws of perspective,—how in the ordinary course of nature these laws are never broken by a hairbreadth. They are therefore accustomed to judge in the fraction of an instant the size of an object by its apparent distance away. That this is the result of practice can be easily seen from the fact that very young creatures—human and otherwise—have no idea of the relative distances of objects, and strain to touch a distant gas-light, or, like a young calf, rush headlong into a neighboring wall which their green young fancy deludes them into thinking is really some distance away. But as we grow older we may learn many things, and perspective among others.



STRANGE FISH AND REPTILES

OUR WATER PLAYMATES

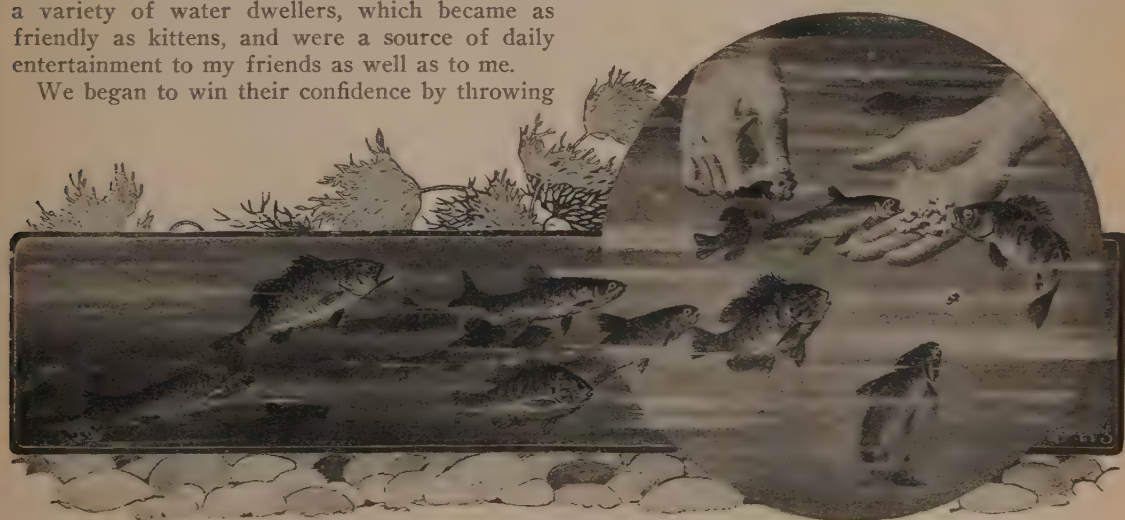
TAME fish are not common pets, yet they are very interesting, as I have found from experience. That others, if inclined, may find ways of enjoying the dwellers of the deep without taking their lives, I will tell of a school of fish that entertained us one summer on the shores of Lake Minnetonka.

Even as a child I seemed to have rather an instinctive feeling of the ways to make acquaintance with those little dwellers in another element, and I always carried a slice of bread in my dinner basket to drop to the minnows in the brooklet we passed on the way to school; but not being allowed to go down to the water's edge, I never knew them or their habits of life very fully. When I came to live on the lake shore, I gathered a variety of water dwellers, which became as friendly as kittens, and were a source of daily entertainment to my friends as well as to me.

We began to win their confidence by throwing

crumbs to them as we sat in the boats under the willows, but noticing it was hard for them to come to the surface for food, I tried holding bits of bread in the water. At first they all sped away, shyly, but coming nearer and nearer, till one ventured to nip the bread. It was good and harmless, and he tried again. Another came, another and another, till courage, which is everywhere contagious, spread among them, and as the days went by they seemed almost to forget fear and always swam eagerly to meet us when we went down to the lake shore.

For a time I always whistled to call them in, but later I went silently and found them just as ready to greet me as when I called. I noticed, though, that if we ran out on the pier heavily, or



"NOTICING IT WAS HARD FOR THEM TO COME TO THE SURFACE FOR FOOD, I TRIED HOLDING BITS OF BREAD IN THE WATER."

rocked a boat on the water, they flocked in more speedily, which fact coincided with the observations of scientists, that fish are in some way very sensitive to vibrations of the water.

In our bay the sunfish tribe was most numerous and fearless. I often put my two hands together like a dish, and holding them under the water they were instantly filled, crowded with the soft, velvety little things. There never was anything smoother and softer than a living fish in water! Rose petals would be rough in comparison.

We never startled them by taking them out of the water; had we done so the spell would, doubtless, have been broken and we should have had no tame fish. The only one I ever took from its native element was an unfortunate that had been lured by a hook and though escaping with his life had the hook still hanging in his mouth. This I removed and returned him again to the water, relieved from what was probably a painful inconvenience, though terrified and distressed; but after performing that surgical operation I was never able, if he remained with us, to distinguish him from others.

These little fellows grew very fast with the good living provided, but we no more thought of making a meal of them than of our sweet-voiced canaries.

At the end of the pier, under a sunken log, where a few water plants had taken root, was a family of catfish, horned pout, that joined our group. They were black, scaleless fellows, with large, flat heads, wide mouths, and slender, black whiskers growing just above the corners of the mouth. Not great bread eaters, but ravenous when offered a piece of meat. It was very amusing to give them a bone to pick, to feel their strong pull as they snatched it away, and see them dash down to the bottom of the lake with it, looking as if they stood on their heads; then rushing about till the water was turbid with their efforts to devour the last morsel.

One morning a long, slender pickerel came and made his abiding-place with us. He was very much of an aristocrat, always holding himself a little aloof from the others, and never tempted to come to their table by any variety of food I could offer; though he came close and seemed never offended when I stroked his smooth sides. I always noticed what a cruel-looking face he had and wondered if it was because he was very hungry. Most of the time he held himself nearly motionless in the water, but when he did move it was like a lightning flash; then all his finny compan-



"THEY WERE BLACK, SCALELESS FELLOWS, WITH LARGE, FLAT HEADS, WIDE MOUTHS, AND SLENDER, BLACK WHISKERS GROWING JUST ABOVE THE CORNERS OF THE MOUTH."

ions disappeared. Making a circle through the water he would return to his usual position near the boat, watching with his set eye as if he were the appointed ruler there.

After a time, my brother coming down to the lake saw him, and asked, "How long do you think your school of fish will hold out to feed that cannibal?" The words were a revelation. It was surprising I had never suspected his strange manners, especially as I had noticed that he always seemed to be swallowing something when he returned from his flights through the water. "Beside," Brother added, "he could snap off your finger at a single bite if he chose."

There was no longer a welcome for our pickerel; instead, a willow branch was struck vigorously through the blue waves whenever he approached, and soon he came no more.

Some turtles found us out and four came regularly to meals. Two were about eight inches in diameter, the other two not more than four or five inches. Their shells were beautiful on the under side, mottled with red, yellow, and brown. I never felt very trustful of them and always took a large piece from the dish when I saw their black heads drifting through the water. To this they would swim and, resting their front feet upon it, bite off one mouthful after another till satisfied, never seeming very particular what kind

of food was provided; then they would go to the shore and doze in the sunshine.

Among the smaller varieties in our group, the least trusting and the most beautiful was the yellow perch. Their greenish golden sides, banded with narrow lines of black, glistened where the sunlight pierced the water and always called forth expressions of admiration. But few of them came, and before summer was gone, all seemed to have disappeared.

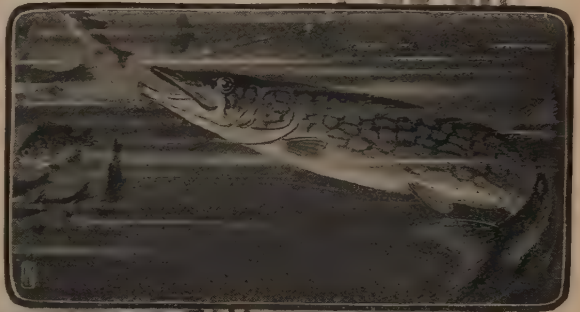
The most friendly, undisturbed individual in our living collection was a black bass. He was a little more than a foot long when we first noticed him. He seemed to make his abode in a growth of water-mosses near a fallen tree, and no one ever went down to the shore that he did not swim majestically out to meet him, opening his great mouth as he neared the surface for an expected morsel, and very seldom was he doomed to disappointment. If we were slow in offering it, he would come as close as possible to shore, never hesitating to eat from out our fingers, seemingly no more afraid of us than we were of him.

He was a rollicksome, jolly fish, never troubled about the necessities of life, and seemingly satisfied with its conditions. Every one felt like laughing when one saw him, and it really seemed as if he enjoyed companionship.

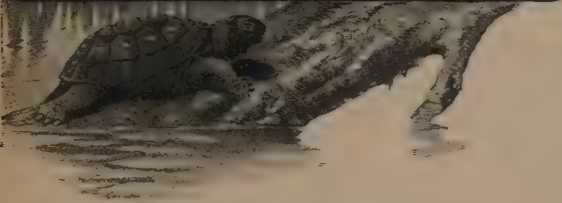
He remained with us till we left the lake, and one of the family going out to the cottage in No-

It was a pretty sight when our yacht steamed out from shore to see the wake of fish that followed it; and it was especially pleasing to watch them come to meet us on returning, as they always did.

No one thing gave us more pleasure



"WHEN HE DID MOVE, IT WAS LIKE A LIGHTNING FLASH."



"I SAW THEIR BLACK HEADS DRIFTING THROUGH THE WATER."

during that happy summer by the lake than our tame fish, yet we resolved never to feed them another season, for our bay grew to have a reputation as a fishing-ground, and it was very grievous to see the stolid, old fishermen sitting by the hour pulling into their boats the trusting little creatures that we had disarmed by dispelling their fears. But for one who has a lake or stream wholly his own, I know of no pleasanter pastime than making friends with the dwellers there.—SARAH A. JENISON.

THE TOAD UNDER THE BRICKS

SOMETIME near the last of June we were removing the bricks from a short walk in order that we might replace them with others to match the pattern of the walks around the house.

Near the center of the walk, and about equally distant from either side, we found under the bricks, in a space just large enough to accommodate him, a full-sized toad.

It is not at all probable that he could have burrowed from either side of the walk beneath the bricks, and it was utterly impossible for any but the tiniest of toads to have forced a way between

vember found him still there, and seemingly glad to see an old friend.

the bricks, as they were placed as closely together as bricks are usually laid, and were in perfect condition.

He was not in the most excellent flesh; in fact, was a pretty slender specimen of toad; and was disinclined, at first, to exert himself at all. He sat very quietly and blinked when we poked him gently, and only showed a feeble inclination to hop when we had removed him forcibly from his cave.

We watched him for a day until he became more familiar with our back yard, and were gratified to find that the hopping instinct was there all right, and only needed space for rapid development.

How and when had he got into his subterranean home, how long had he lived there, what had he lived on, and why, if he had a way to get out, had he not been out sooner, when all ambitious toads had been reveling in flies and bugs and summertime for a month or more?

OLIVE RACHEL WHITE.

The common toad has a marked habit of burrowing under brick walls. I think he does this owing

to his discovery that bricks absorb a comfortable amount of heat from the sun, and while he is in

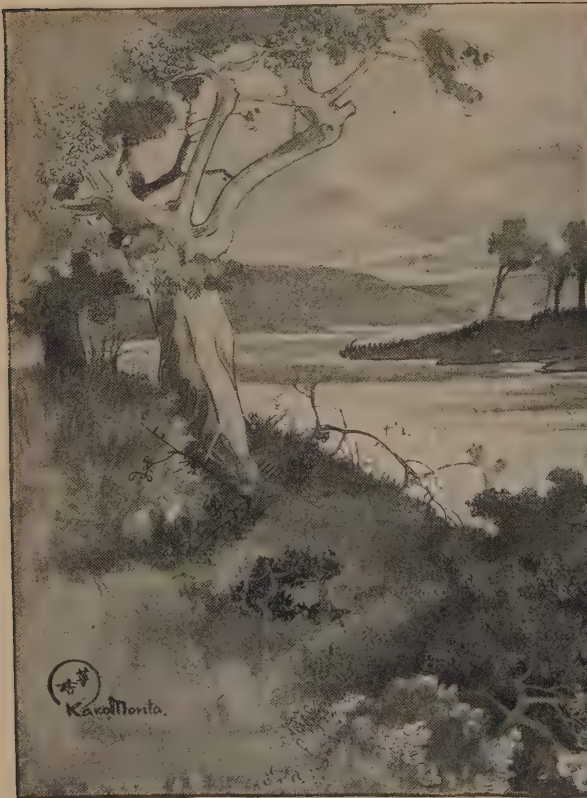


THE TOAD UNDER THE BRICKS.

darkness during the day, as he desires, he is also well-warmed. This toad, of course, burrowed in from the side. It is possible that the earth was of a consistency that caved in after him and he was, for the time being, too lazy to burrow out again, which might quite naturally be the case if the season were inclined to continue cool.—R. L. D.

THE MIGRATION AND "RUNNING" OF LAMPREYS

In the spring lampreys in large numbers ascend the streams and even waterfalls to their spawning places, which may be several miles from the ocean or lakes in which they usually live. This migration is some-



THE LAMPREYS ASCENDING A STREAM AND WATERFALL.

what similar to that of birds that go north in the spring to build nests and rear their young. Professor H. A. Surface, who has studied the lampreys (principally in New York State), thus writes:

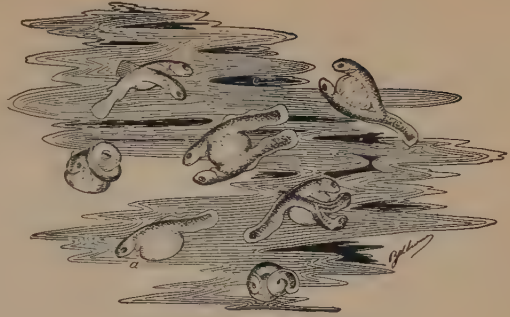
"In this migration they are true to their instincts and habits of laziness in being carried about, as they make use of any available object, such as a fish, boat, etc., that is going in their direction, fastening to it with their suckorial mouths and being borne along at their ease. During this season it is not infrequent that as the Cornell crews come in from practice and lift their shells from the water, they find lampreys clinging to the bottoms of the boats, sometimes as many as fifty at one time. They are likely to crowd up all streams flowing into the lake, inspecting the bed of the streams as they go. They do not stop until they reach favorable spawning sites, and if they find unsurmountable obstacles in their way, such as very high vertical falls or dams, they turn around and go downstream until they find another, up which they go. This is proved every spring by the number of adult lampreys which are seen temporarily in Fall Creek and Cascadilla Creek. In each of these streams, about a mile from its mouth, there is a vertical fall over thirty feet in height which the lampreys cannot surmount, and in fact they have never been seen attempting to do so. After clinging with their mouths to the stones at the foot of the falls for a few days, they work their way down-stream, carefully inspecting all the bottom for suitable spawning sites. They do not spawn in these streams, because there are too many rocks and no sand, but finally enter the only stream (the Cayuga Lake inlet) in which they find suitable and accessible spawning sites.

"In 'running' they move almost entirely at night, and if they do not reach a suitable spawning site by daylight, they will cling to roots or stones during the day and complete their journey the next night.

"They do not swim readily over a fall, but cling with the mouth to stones, and jump and catch and cling and jump again. If the falls be low, they of course could go over them, but I have seen them clinging in the way I describe."

QUEER LITTLE FISHES

BABY fishes sometimes appear in as strange forms as the famous Siamese twins. Our illustration shows a few of these little fishes selected from a collection of fifty thousand newly hatched rainbow trout, at the Central Station of the U. S. Bureau of Fisheries.



THE QUEER LITTLE FISHES.

Among the many millions of trout and salmon from the government hatcheries these odd forms are sometimes found. Usually the twins are attached on opposite sides of the same egg-sac and are otherwise normal in form, like the fish shown in the sketch by *a*. Two-headed and, very rarely, three-headed forms occur, and curiously twisted specimens, with corkscrew-tails. Although lively enough when first hatched, most of these abnormal fishes do not survive longer than the period of ten or fifteen days necessary to absorb the food of the egg-sac, and it is unlikely that they would live any longer in natural conditions.

A. H. BALDWIN.

A SIMPLE TURTLE TRAP

ANY stout box about eighteen or twenty-four inches square and eighteen inches deep will answer the purpose. Bore a few holes in the bot-



A TURTLE TRAP SET IN A SMALL POND.



"WAIT FOR A FAVORABLE CHANCE TO GRAB THE UPPER AND LOWER JAWS."

tom and sides for water circulation, nail an inclined board as a gang-plank on one side extending from the water to about over the center of the box.

The box should be weighted with stones to keep it level, leaving only about six inches above the water. The trap is then ready to anchor in any convenient place in the pond or lake.

The turtles in selecting a fine spot in which to sun themselves will invariably crawl to the highest point of the gang-plank, directly over the center of the trap. It is then necessary only to throw a stone from a distance in order to make a good splash near the trap. The turtles becoming frightened will slip off the gang-plank into the trap.

The writer has caught many turtles in this manner in a very short time. W. L. BEDELL.

HANDLING ALLIGATORS

THERE is a man with the quite unheroic name of Bert Swan who catches alligators with his hands, turns them on their backs, and makes them as helpless as infants. The alligators that Swan does this with are not the giants that bask in the mud of tropical rivers, but they are sufficiently formidable nevertheless. It is wonderful with what quickness these saurians can snap at a man.

Swan gave a little session with his pets for the benefit of the camera man, and this quickness of action on the part of the alligators was fully demonstrated before the little private performance ended.

The first task was to get the alligator into the open where the light was sufficiently good to permit of snap shots. This was done by two men grasping the alligator, one seizing his jaws with a lightning movement and the other grabbing his wildly waving tail. In the open the alligator

proved as wicked as could have been wished. Swan's method of catching him was to hold the hands in readiness and wait for a favorable chance to grab the upper and lower jaws. As this was done while the formidable rows of teeth were apparently aching for a chance to snap the man's arm, it was no simple matter to catch the jaws and imprison them.

Swan waited a long time before he saw his chance, and the eye could scarcely follow the movement of his hands as they were darted toward the outstretched jaws. Once the jaws were closed in the man's vise-like grip it was a simple matter to slip one hand under the snout, seize one of the clawing legs with the other, and turn the alligator on his back.

The owner of the alligator says he has found



A CURIOUS PLAY WITH THE ALLIGATOR.
The mouth opens when the hands are held apart.

a way to hypnotize the creatures. Be that as it may, it is true that he made the wicked little saurian lie perfectly still for as long a time as he wished, and then raised him in his arms and carried him around like a baby, the animal being apparently sound asleep all the time. When Swan put him down and touched his throat with a finger, he awoke once more into vicious life and began snapping as before.

The alligator cannot move very quickly on his legs, and it is easy enough to avoid him when he comes at you, but to try and pinion his jaws is another matter, and a task that no one would care to try unless gifted with lightning-like agility and the quickest of eyes, as well as with muscular hands.

Small alligators may be purchased at most animal stores, and are as easily cared for as are frogs and turtles.

H. D. JONES.

A MUCH ADVERTISED TOAD

AFTER a blast about one hundred feet below the surface in the lime rock of a mine thirty miles north of Winnemucca, Nevada, Mr. Charles Van

The toad was undoubtedly there, it was found by Mr. Van Zandt, and it later was given a fly to eat. This last fact was announced in such startling headlines as "Pythagoras, the Toad, Eats His First Meal in a Thousand Years."

Mr. Van Zandt kept the toad at his home in a porcelain jar for about seven months, the little animal steadily refusing all food. A representative of the miner coming to New York reported the matter to Dr. Gratacap, at the American Museum of Natural History, and he at once referred it to the New York Zoölogical Park, where the toad was placed on exhibition in the Reptile House.

Mr. Raymond L. Ditmars, the manager of that house, made a statement as follows:

It's pretty hard to form any definite opinion as to the age of toads found "imprisoned" in rocks, etc. I really believe that a toad might live for a hundred years under normal conditions. I have known them to live for a year without food and be normally active. It is quite possible an imprisoned toad, with partially suspended animation, might live many years. The matter is one of theory only, however. I am after proof as to how long this toad was a prisoner. He might have worked his way downward through a series of continuous crevices, and in this case would have undergone no abnormal fast.

This particular species of toad is known as the "spade-foot," and is famous for its underground habits.

Miss Mary C. Dickerson, a careful student of toads and frogs, writes of its habits in "The Frog Book" (Doubleday, Page & Company) as follows:

It burrows into the ground and sleeps days or weeks, perhaps years, at a time. A gravedigger once found one three feet two inches from the surface of the ground, with no evident exit to the burrow. . . . Except during the breeding season, the spade-foot is found only by accident. It sits in its burrow, showing only its peculiar golden eyes at the doorway. The turnip-shaped burrow is about six inches long and somewhat oblique in position. The earth on the interior is hard and smooth, packed into this condition by a continued energetic turning-about on the part of the owner of the burrow.

It is true that the habits of this species and the location of this particular specimen are astonishing, but in this respect have not equaled the many statements that have recently been printed with startling headlines.

THE HOUSE-SNAKE; ALSO CALLED THE MILK-SNAKE

My grandmother was sitting one day in her arm-chair in front of an old-fashioned cupboard, when, to her very great surprise, a house-snake fell into her lap and wriggled to the floor. In



THE TOAD THAT WAS FOUND IN A MINE.

Photograph by courtesy of the New York Zoölogical Society.

Zandt (a Butte, Montana, mining man) picked up among the pieces of rock a much dazed toad. Undoubtedly it was a very interesting form of animal life (most toads are), and it was in an unusual place. It would be interesting to know by what series of cracks and crevices he got down there or how long he had been there without food or what food, if any, he had obtained.

But all these queries are excelled in interest by the astonishing messages sent all over the country by the Associated Press, and the industry and zeal with which almost every newspaper in the United States served up the great "information" for the news appetites of its readers.

some way the snake had found its way into the house unobserved, perhaps through an open door or window, and had crawled to the top of the cupboard in search of food.

The first name given to this reptile was well chosen, for it is found about houses and other buildings more frequently than any other snake. I remember when I was a boy in the country to have seen several about the porch of the house, but they invariably made their escape, just to give mother the shivers as she recalled grandmother's experience of long ago. Mother would on these occasions declare that I let the snake get away on purpose, but who ever heard of a boy permitting a snake to escape if he could prevent it?

Ophibolus doliaulus triangulus (Boie.) is also known as the milk-snake, although it most likely cares no more for milk than would any other thirsty ophidian; but because it frequents spring houses, in which milk is kept, to catch frogs and salamanders which live in these cool places, the owner of the milk could not resist the temptation to give it a new name. Another of its many



THE MILK-SNAKE.

local names is "thunder-and-lightning snake," but I cannot imagine why so gentle a serpent should be so named. It is perfectly harmless. Recently I saw a frightened specimen bite a school-girl, but she only laughed. An uncle of mine once caught a house-snake lying on a shelf in his store. Knowing its value he placed it in his corn-crib, where it remained all summer. It is needless to say that the mice quickly disappeared. Besides mice and rats the house-snake catches many



THE SNAKE CLIMBING A TREE.

crickets, grasshoppers, cockroaches and other insects. It is very beneficial to the farmer and should never be killed.

It varies much in color but the markings are very distinct. Gray or silvery bands and reddish-brown blotches mark the back, while beneath it is checkered with black and yellowish-white, making this a handsome reptile. Frequently when disturbed it sets its short tail vibrating as many other snakes do when angry. It is an expert climber, but seldom climbs trees, preferring to creep about old houses and barns. On one occasion I knew of one climbing up a small tree a few feet to a bird's nest.

Those who care to handle reptiles will find the house-snake an interesting pet. It sometimes reaches a length of four feet; specimens ordinarily, however, are less than three feet. The young are hatched from eggs.

ARTHUR RUSMISSELLE MILLER SPAID.

THE GIANT FISHES OF THE SEA

MANY people, including some scientists, believe that there exist in the sea to-day monster animals—sea-serpents, leviathans, and giant fishes—



A MAN-EATER SHARK IN THE WAKE OF A VESSEL.
(It is about forty feet long when full-grown.)

which have never been captured, and hence are unknown to zoölogists and have no place in scientific books. Whatever may be the facts in regard to such creatures, there are well-known members of the fish class which deserve to be regarded as monsters, and which may have given rise to the sea-serpent stories. Some of the most noteworthy of these fishes are here referred to and illustrated.

At the mention of giant fishes, many young folk will at once think of the sharks, among which, indeed, are found the largest existing fishes. Of the numerous kinds of sharks noteworthy on account of their size, there are four in the front rank; these are the sleeper-shark, the man-eater shark, the basking-shark, and the whale-shark.

The sleeper-shark, whose scientific name (*Somniosus microcephalus*, meaning sleepy small-headed fish) fits it so admirably, appears to have developed its body at the expense of its brain, for it is a sluggish, stupid glutton, about six times as long as the average man. Its home is in the arctic regions, but it sometimes makes visits as far south as Massachusetts, Oregon, and the British Isles. It is usually seen lying quietly at the surface, apparently dozing, and is easily approached by vessels; but sometimes, when hungry, it rouses itself and goes in search of its prey, fiercely attacking and injuring whales, apparently unconscious of the great difference in their respective sizes.

One of the largest, and perhaps the most formidable, of sharks is the "man-eater," or great blue shark (*Carcharodon carcharias*). It roams through all temperate and tropical seas, and is everywhere dreaded. Its maximum length is forty feet, and its teeth are three inches long. While there are few authentic records of sharks

attacking human beings, there have undoubtedly been many cases of sharks simply swallowing people who have fallen overboard, just as they would swallow any other food. How easy it would be for a man-eater to devour a person, may be judged from the finding of a whole hundred-pound sea-lion in the stomach of a thirty-foot shark on the California coast. A certain man-eater, thirty-six and a half feet long, had jaws twenty inches wide inside, and teeth two and a half

inches long.

The basking-shark, known also as the elephant-shark and bone-shark (*Cetorhinus maximus*), is an inhabitant of the polar seas, but is occasionally observed as far south as Virginia and California, and some years ago was not rare on the English and New England coasts. It reaches a maximum length of fifty feet, and is exceeded in size by only three or four animals now alive. Provided with small teeth, it feeds on fishes and floating crustaceans, and is not of a ferocious disposition. It is dangerous only because of its great bulk, and when attacked its powerful tail easily demolishes small boats. The basking-shark was formerly hunted on the coasts of Norway and Ireland for its oil; it was also sought on the shores of Massachusetts in the early part of the last century; and many of these sharks from twenty-five to thirty-eight feet long were recorded. The liver of a large specimen sometimes yielded twelve barrels of oil.



A SAWFISH ENTANGLED IN A NET.
(This fish is about twenty feet long when full-grown.)



OCEAN SUNFISH SUNNING THEMSELVES.
(They are about eight feet long when full-grown.)

The largest of all fishes, the largest of all cold-blooded animals, and the largest of all existing animals, except a few kinds of whales, is the whale-shark (*Rhineodon typicus*), originally discovered at the Cape of Good Hope, but now known in Japan, India, South America, Panama, California, and elsewhere, a specimen having recently been obtained in Florida. This shark is said to attain a length of seventy feet, and is known to exceed fifty feet.

A fish of such peculiar form that the Italians call it *mola* (millstone), and the Spaniards *pez luna* (moonfish), is known to Americans and English as the sunfish, for it appears at the surface of the ocean on bright days and spends many hours basking listlessly in the sun, sometimes lying flat with one side out of the water, sometimes with the back fin projecting like a buoy above the surface. The fish is disk-shaped, its height nearly equaling its length. It is one of the most grotesque of fishes, being apparently nearly all head. Of almost world-wide distribution, it is particularly abundant on the southeastern coast of the United States and on the California coast. It swims but little, being

usually content to be drifted along by the ocean currents. The Gulf Stream wafts many a sunfish north each summer, so that the species is not rare off southern New England. That the fish deserves a place on the list of giant fishes may be judged from the fact that examples weighing from two hundred to five hundred pounds are not rare, and that much larger ones are occasionally met with. The weight of the largest known specimen, caught in 1893, at Redondo Beach, California, was eighteen hundred pounds. On such a monster, lying on its side, there would be room for thirty men to stand.

In the lagoons, sounds, and bayous of the West Indies and our southern coast, there exists in abundance a fish of great length, called the sawfish. The species is well known to those who reside on or visit the South Atlantic and Gulf seaboards, and the "saws" are familiar objects in "curio" stores all over the country. This fish has a broad, depressed body, and its greatest length exceeds twenty feet. The largest examples have saws six feet long, and a foot wide at the base, with teeth several inches long. The sawfish is without commercial value, and is never sought, but it has a way of getting entangled in the fishermen's nets and badly damaging them in its struggles to escape, so that the fishermen regard it as a nuisance, and have to handle it with care in order to avoid the serious injury that might be inflicted by a lateral sweep of a big fish's saw.

The valuable mackerel family has one member which easily ranks first in size among the "bony fishes," as distinguished from the sharks, rays, sturgeons, etc., which have gristly skeletons; this is the horse-mackerel, or great tunny (*Thunnus thynnus*), whose range encircles the globe, and which is an object of fisheries in many countries, notably southern Europe. Built on the compact and graceful lines of our common mackerel, it



A HORSE-MACKEREL, OR GREAT TUNNY, CHASING MENHADEN.
(The great tunny is about fifteen feet in length when full-grown.)



GIANT RAYS, OR DEVIL-FISHES.
(They are about twenty-five feet wide when full-grown.)

excels in speed, alertness, and vigor among the fishes of the high seas, and might very easily make a trip across the ocean in one third the time of our fastest steamships. It preys on all kinds of small fish, and is often seen playing havoc among schools of luckless herring and menhaden. Fifteen feet is about its maximum length, and fifteen hundred pounds its estimated maximum weight, although it is likely that this weight is considerably exceeded. Thirty tunnies harpooned by one fisherman during a single season weighed upward of thirty thousand pounds. A mutilated specimen ten feet long was found by the writer on the coast of Massachusetts; its head weighed two hundred and eighty-two pounds; its carcass about twelve hundred pounds.

Among the rays are several members which reach colossal proportions. The largest and best known of these is the so-called "devil-fish" (*Manta birostris*) of our South Atlantic coast and the tropical waters of America. It occasionally strays as far north as Cape May, and is common south of Cape Hatteras. It is shaped like a butterfly or bat, and has been called the "ocean vampire." Projecting from either side of the head is a horn-like appendage, which, in reality, is a detached part of the pectoral fin, or "wing"; these horns, to which the name "devil-fish" owes its origin, are sometimes three feet long, and are movable, being used for bringing food to the mouth. Many years ago, the pursuit of this fish was a favorite pastime of the Carolina planters; and William Elliott, in his "Carolina Sports by Land and Water," says: "Imagine a

monster from sixteen to twenty feet across the back, full three feet in depth, possessed of powerful yet flexible flaps or wings, with which he drives himself furiously in the water, or vaults high in the air." There are well-authenticated instances of this fish entangling its horns in the anchor-ropes of small vessels and towing the vessels rapidly for long distances, to the mystification of the people on board. The expanse of body is greater in this species than in any other known animal. Examples sixteen feet wide are common, and those twenty feet across and over four feet thick are not rare. The maximum width is stated by authors to be from twenty-five to thirty feet. One specimen, of which the writer has a photograph,

caught in Lapaz Bay, Mexico, many years ago, by the crew of the U. S. S. *Narragansett*, of which Admiral Dewey was then captain, was seventeen feet wide and weighed nearly two tons. A fish of the largest size mentioned would weigh not less than six tons.

HUGH M. SMITH.

THE TUATERA

TUATERAS are a curious species of the lizard tribe, which exists only in New Zealand, and then only in some parts of that country, as Stevens Island in Cook Strait.

An authority on tuateras says: "I once had two, many years ago, who appeared to live happily for a couple of months on the 'light of other days'; for they ate nothing—they sometimes would not move for a day or two."

The most curious thing about them is that they have helped explain the existence of a certain gland that we have in our heads. The tuatera has the same gland, only in a far more developed state; and this gland is "the nearest approach to a third or pineal eye of any known animal; in fact, the eye is fairly developed, but is hidden under the skin between the eyes they use for every-day use." Tuateras are of a brown color, with tiny white spots all over them, the spots being larger and whiter on the throat and stomach; they enjoy burrowing into the earth, also basking in the sun and catching flies. The word comes from *tua*, the back, and *tara*, a spine, that is, spiny-back.



THE LARGEST ANIMALS

The lighthouse-keeper's little daughter carrying dinner to her father in the lighthouse. She sees a drove of whales "spouting" near to the shore and points them out to her dog.

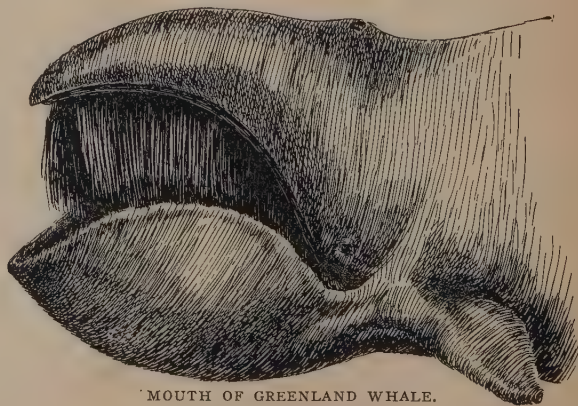
ROAMING singly or in "droves" through all the oceans, from the tropics to the poles, are many kinds of immense creatures, fish-like in shape and popularly regarded as fishes, but hot-blooded, air-breathing, and having little in common with fishes except the element in which they live. These, the whales, dolphins, grampuses, and their tribe, called collectively cetaceans, are the real monarchs of the seas, and in size and length surpass any other animals of either land or water which now exist, or which are known to have lived in ancient times. From a very early period whales have been hunted by man, and they have added more to the wealth and prosperity of the civilized world than any other group of wild warm-blooded animals.

In order that they may keep warm, whales are completely incased in a thick layer of fat or blubber, from which is made the whale oil of commerce. In former years it was profitable to hunt whales for this oil, but petroleum and fish oils have to a great extent replaced whale oil and have so reduced its market value that whales would now rarely be killed by man if they did not yield several more important products.

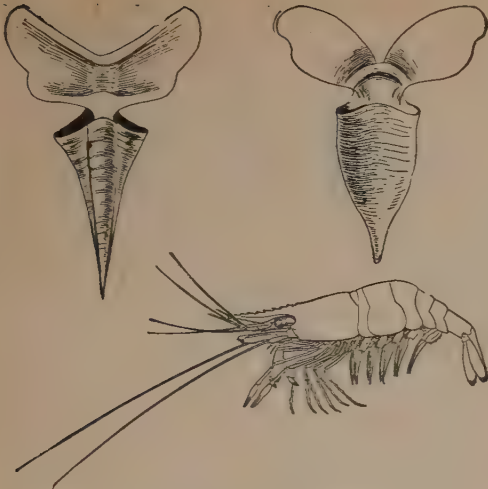
One group of whales have teeth in the lower jaw but none in the upper jaw. The largest and most valuable of these toothed whales is the sperm-whale, or cachalot, which has a head of strange shape and with strange contents. The lower jaw is long and narrow, and has a row of large conical teeth placed far apart; and it is so loosely joined to the skull that in feeding it may

be dropped to an almost vertical position and also swayed from side to side. The upper part of the head is an immense straight-sided mass, with the blow-hole or nostril at the top of the flat nose. In the head is a natural oil-well—a large cavity filled with sperm-oil, of which more than twenty-five barrels have been taken from a single whale.

The sperm-whales sometimes reach a length of eighty-five feet, and those seventy feet long are not uncommon. They go in schools which may contain hundreds of individuals, and are found in all parts of the world except the polar regions. They feed mostly on squids, cuttle-fish, and devil-fish, and they are able to destroy the largest of these animals.



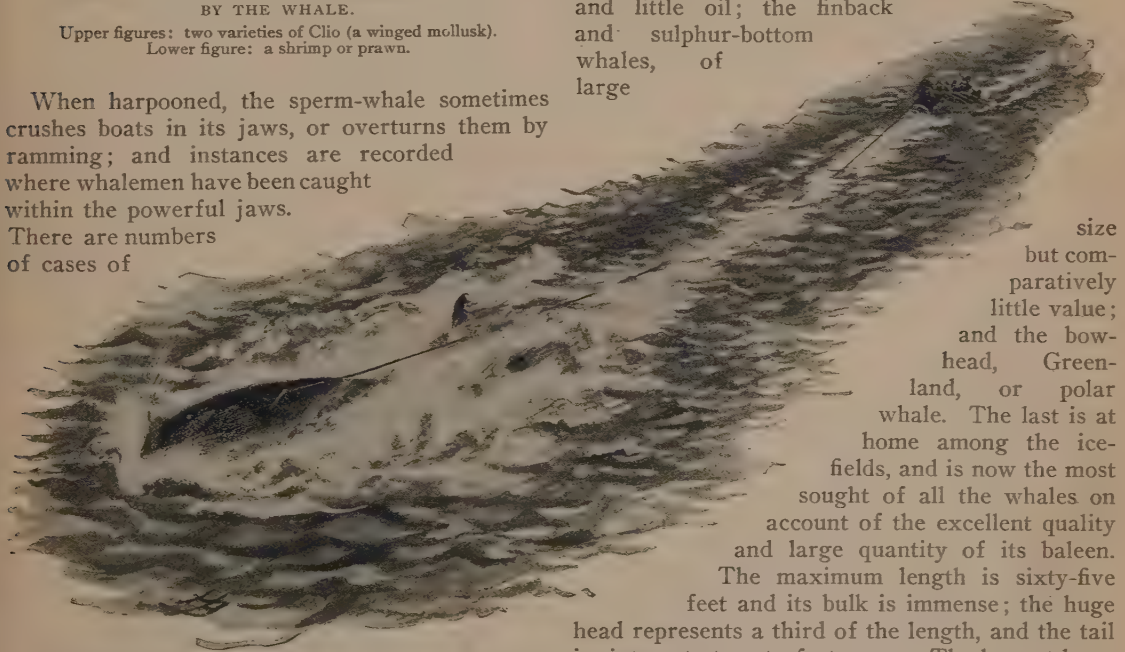
MOUTH OF GREENLAND WHALE.
Showing strainers (baleen).



SOME OF THE MANY SMALL ANIMALS EATEN
BY THE WHALE.

Upper figures: two varieties of *Clio* (a winged mollusk).
Lower figure: a shrimp or prawn.

When harpooned, the sperm-whale sometimes crushes boats in its jaws, or overturns them by ramming; and instances are recorded where whalers have been caught within the powerful jaws. There are numbers of cases of



A HARPOONED WHALE TOWING A BOAT-LOAD OF WHALERS
THROUGH THE WATER AT A RAPID RATE.

vessels being attacked by sperm-whales without provocation, and probably some vessels which have disappeared at sea were wrecked by these leviathans. In 1820 the American ship "Essex" was rammed twice by a sperm-whale, and sank ten minutes after the second assault.

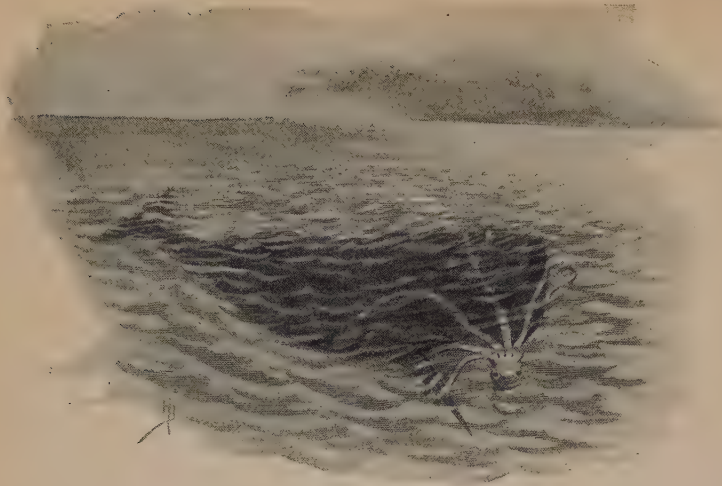
Another group of whales have no teeth, but the mouth is provided with several hundred closely packed horny, flexible plates or slabs suspended from the roof of the mouth and hanging on each side like a curtain, so that when the mouth is

opened as wide as possible their ends are received within the lower jaw. These plates, which in some whales are nine or ten feet long, have pointed, frayed extremities, and are lined with long, stiff hair. This peculiar substance in the mouth of whales, which is called baleen, or whalebone, although it is not bone, is now the most valuable product which is yielded by these creatures; and to obtain it thousands of men brave the dangers of the seas, of the arctic ice, and of the chase, killing the whales by hurling harpoons and shooting explosive bullets into them from a small boat.

Among the various kinds of whalebone-whales is the right whale, which reaches a length of sixty feet and yields two hundred barrels of oil and a thousand pounds of long, valuable baleen; the humpback whale, which is sometimes seventy-five feet long, but has short bone and little oil; the finback and sulphur-bottom whales, of large

size but comparatively little value; and the bowhead, Greenland, or polar whale. The last is at home among the ice-fields, and is now the most sought of all the whales on account of the excellent quality and large quantity of its baleen. The maximum length is sixty-five feet and its bulk is immense; the huge head represents a third of the length, and the tail is sixteen to twenty feet across. The largest bowheads produce several thousand pounds of bone worth five or six dollars a pound, and six thousand or more gallons of oil worth forty cents a gallon.

In feeding, the baleen whales drop the lower jaw and swim forward rapidly, and all kinds of small floating animals—fish, shrimp, winged mollusks—pass into the yawning mouth. When the lower jaw is closed, the plates of baleen are forced upward and backward, the water rushes through the sieve formed by the hairs, the food is left behind, and is swallowed by the aid of the tongue.



SPERM-WHALE DEVOURING A LARGE OCTOPUS.

Some of the baleen whales are said to attain a length of more than a hundred feet, and there are authentic records of examples measuring between ninety and a hundred feet. The largest species of whale, and therefore the largest of all living animals and the largest creature that ever existed, so far as we know, is the sulphur-bottom whale of the Pacific coast. One of these was ninety-five feet long and thirty-nine feet in circumference, and weighed by calculation nearly three hundred thousand pounds. The sulphur-bottom whale is further distinguished by being the swiftest of all whales and one of the most difficult to approach; it glides over the surface with great rapidity, often displaying its entire length; and when it respires the immense volume of vapor which it throws up to a great height is evidence of its colossal proportions.

On one occasion a sulphur-bottom whale remained with a ship for twenty-four days, often passing under it and touching the hull; although it was shot with rifle-balls and struck with logs of wood and other missiles, it refused to desert the vessel until it entered shallow water.

Most savage and power-

ful monsters are the orcas, or killer-whales, which, while comparatively small as whales, are so rapacious, active, and strong-jawed that no other animals, not even the fiercest of man-eater sharks and the largest of whales, can withstand their awful onslaughts. Favorite objects of their assaults are the toothless whales, and some of the bloodiest fights occur when mother whales are attacked while guarding their young. The orcas hunt in small droves, and are veritable ocean wolves, surrounding their prey, tearing great pieces from the lips and throat and biting out the tongue, the whales drowning, or dying from loss of blood.

HUGH M. SMITH.

THE LARGEST FLYING CREATURE

WE are apt to think of reptiles as creeping and crawling things, forgetting that there was a time when flying reptiles were more common than birds. These reptiles, the pterodactyls, or flying dragons, not only flew, but some of them reached a size much greater than that of any bird, for the largest birds do not fly. The South American



A DROVE OF ORCAS ATTACKING A BOWHEAD WHALE.

condor sometimes measures as much as ten and one-half feet from tip to tip of outstretched

in the air. And how did he start to fly? With such enormous wings, we think *Ornithostoma* must have dwelt on cliffs about the sea and launched off them. This great flying reptile lived some six million years ago. The sea over which it flew long ago disappeared, the mud into which its bones sank became chalk, and from the formation of these great chalk-beds the time at which



THE ORNITHOSTOMA—THE LARGEST FLYING CREATURE.

wings, and it is quite possible that the finest examples of the albatross may measure a little more. But the great pterodactyls which flew about the sea that in the days of old reached from the Gulf of Mexico to the Rocky Mountains measured as much as twenty feet, the width of an average city lot, across their wings. Many of us have seen an eagle flying, and we can appreciate the size of this ancient dragon by remembering that it was nearly three times the size of an eagle. It was not, however, three times as heavy, for the body of this strange reptile was so small and its skeleton so wonderfully light that the entire animal is thought to have weighed not more than twenty-five pounds, or only about as much as a large condor. One of the largest bones of the wing, two feet long and two inches through, was, as Professor Williston tells us, no thicker than a sheet of blotting-paper, and the great head, with a beak over three feet long, was equally light. This great toothless beak is believed to have been used for snapping up fishes; and we can imagine this huge creature sailing swiftly over the sea, now and then swooping down to pick up a fish as deftly for all its size as a real swallow. But what did *Ornithostoma*—this is the creature's name—do with his wings and beak when he made an occasional visit to the land? One would think they must have been very much in his way, and that the animal

Ornithostoma existed is called the Cretaceous Period.

FREDERICK A. LUCAS.

Of birds now in existence, probably the one with the greatest expanse of wing in proportion to the body, and with the greatest power of flight, is the frigate- or man-o'-war bird (*Fregata aquila*). This bird apparently flies more by skill than by strength, for it has no great carrying powers.

The wandering albatross, the largest of all sea-birds, is also one of our strongest fliers. One bird was known to fly at least 3150 miles in twelve days. This bird was caught, tagged, released, and caught again.

HOW THE LOBSTER GROWS

A LOBSTER lays thousands of eggs, most of which hatch, but few ever live to grow up. This is not the fault of the mother, for she carries them about with her for nearly a year, and with admirable instinct guards them as she does her own life. When the young are set free, her duty is done, for they must then shift for themselves. Though hardly larger than mosquitos, being about one third of an inch long, the little ones leave their parents on the bottom and swim to-

ward the light—to the surface, where, from one to two months, if fortune favors them, they lead a free, roving life. The open sea is a poor nursery for such weaklings, which become the sport of every storm and the prey of numberless hungry mouths. Out of a brood of ten thousand it would be a rare chance for more than one or two lobsters to reach maturity, or finally to end their career in the kitchen or the chafing-dish.

The eggs are commonly laid in midsummer—and but once in two years by the same individual—and are hatched in May or June. A “hen” lobster, eight inches long, will lay five thousand eggs; and the egg-producing ability grows apace, for at ten inches the average number is ten thousand, and for the sixteen-inch length nearly one hundred thousand. Each egg is a sphere of about the size represented by the capital O in this font of type (one sixteenth of an inch in diameter), of a deep olive color, and is inclosed in a transparent, waterproof sac, or shell, through which the eyes and other parts of the developing lobster can be watched. Not only are these thousands of delicate eggs nicely distributed over the under parts of the lobster’s body, but all are glued to one another, or to the hairs of the swimming feet, with a kind of flexible hydraulic cement, which sets in the water, and holds the eggs fast.

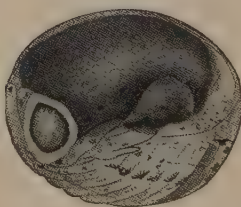
You cannot help the young lobster out of his shell, but must let him escape in his own way, for hatching is a delicate process. His “swaddling clothes” must all come off together, that no energy be lost. The little lobster hatches, molts (“changes his coat”), and unsheathes the swimming hairs of his legs at the same time. The egg-shells stick to both mother and child, while the cuticle of the latter is in turn glued to the swimming hairs of the new skin, so that every tug at the shell helps to free the little lobster from the hampering cloak, and at the same time to perfect his swimming apparatus.

This coming from the shell and molting is always a serious business, and any hitch in the process is likely to prove fatal, especially in the early stages. In this

critical act the entire shell, down to a microscopichair, and everything derived from the external layer of the skin, or cuticle, including the lining of the stomach and the skeleton—for these parts are all formed from folds of the skin—are cast off in one piece. The whole process is dependent on growth, while this in turn is largely a question of age and of food.

During the first year of life the lobster molts about seventeen times, but at its fifth year, when between ten and twelve inches long, not more than once or twice during that year.

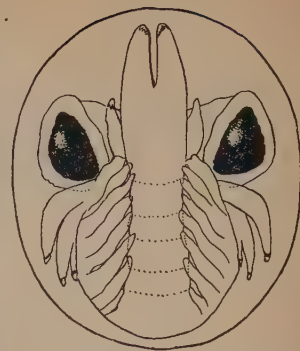
The young, at hatching, are equipped with peculiar swimming organs in the form of six pairs of “oars,” each of which is the outer branch of one of the chewing, grasping, or swimming feet, and is fringed with long, feather-like hairs. The lobster can move forward in any direction by the rapid beating of these flexible oars, or spring backward by a sudden contraction of the tail. At birth the skin is clear as glass, and the colors, now a pale blue sprinkled with vermillion, increase in brilliancy up to the fourth or even to the sixth stage. The body is armed with spines, the most formidable of which, called the beak or rostrum, projects like a spear between the great stalked eyes. As a parting blessing from its parent, the lobster is started in life with provisions for its journey in the little store of yolk left over from the egg; but this is quickly absorbed, and the hungry larva soon begins to snap at floating particles of every kind—sand-grains, and scales of insects, as well as microscopic animals and plants which are its proper food. The young are also very pugnacious, and are cannibals to such a degree that it is almost impossible to rear them in small aquariums.



A SIDE VIEW OF A LOBSTER IN ITS SHELL.

As it is seen when looked at with a microscope through the clear shell.

The eye is the spot at the lower left. The large dark upper part represents the liver and stomach. The part shown as the clear spot at the right forms the heart.



THE BABY LOBSTER WITHIN ITS SHELL. (61 DAYS OLD).

The black spots are the eyes, which develop very early and grow rapidly. Compare with sketch at bottom of first column.



THE LITTLE LOBSTER AFTER 26 DAYS' GROWTH IN THE EGG.

(Diagram showing its form.)

In this

In a few hours or days a second molt and then



THE LARVAL OR FIRST SWIMMING STAGE OF THE LOBSTER.

In this stage it has but little of the "lobster" form. It changes its coat (molts) rapidly as it grows and becomes more and more like the familiar lobster of the markets.

a third are passed, in the course of which, besides a general increase in size, many changes are to be noticed. At the fourth shedding of the skin they seem to pass with a sudden leap to the lobsterling stage, when both in form and habits they resemble an old lobster in miniature, being half an inch long; but they still keep at the surface. The fourth stage marks the turning-point in the lobster's career, and after one or two more molts it sinks to the bottom, never to rise again, unless cast up by the sea or drawn up in a fisherman's trap. Many, after reaching the bottom, move toward the shores and hide in piles of loose



A LOBSTER IN THE FIFTH STAGE.

Becoming "lobster-like" in form. General color, reddish brown.

stone, from which they venture only to capture their prey, and then often at night. When four or five inches long they become bolder and swim farther out to sea, always of necessity keeping to the bottom. Some reach maturity when eight inches long and about three years old.

FRANCIS H. HERRICK,
Professor of Biology in Adelbert College
of Western Reserve University.

THE LIFE ALONG THE SEASHORE

As we walk along the shore at low tide, on the lookout for seaweeds or interesting animals, little jets of sea-water will be seen spurting up from holes in the sand. Let us dig rapidly down under one of these tiny openings and we will catch the spurter, the common soft clam; but if



THE FULL-GROWN LOBSTER AT HOME.

Among the rocks, loose stones, seaweed, and eel-grass. (Drawn from the live lobster in an aquarium representing the bottom of the sea.)



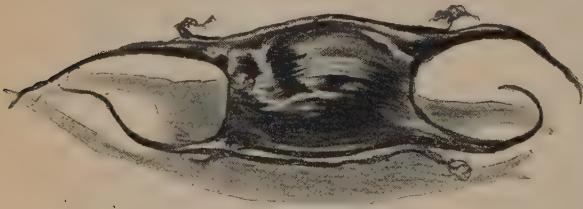
Watching the spurtings of soft clams.

Looking over
specimens.Searching a cave for
anemones, hydroids, etc.

we are not quick enough he will burrow so rapidly as to disappear entirely and only send a last spout of water into our faces, as if in defiance. Place the shell in a glass of sea-water, and when the clam gains confidence he will extend from his shell the long tube-like siphon, and the two openings in the end of it, with their fringed borders, will be seen. Now take a compound microscope or a magnifying-glass and watch the water above the siphon. You will see that it is moving. With the minute life forms it contains, the water sweeps in swirling currents toward one orifice of the tube and plunges suddenly down it; then, after passing over the gills and body of the clam and giving out nourish-

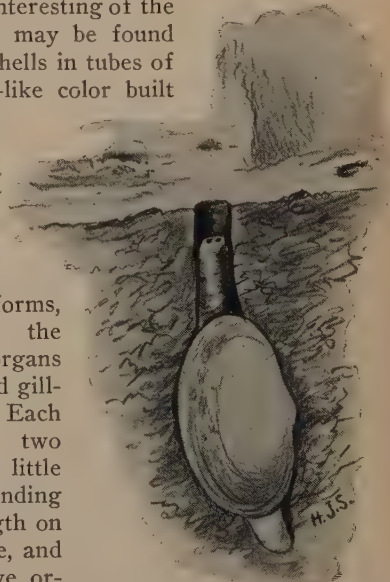
his shell and so hasten this motion, we will see a little fountain shoot up and sprinkle the surroundings, just as they were observed to do on the shore.

Be sure to look for the many worms that may be found, either in burrows in the sand or in tubes which they have built on rocks and stones. All are interesting, and the forms and colorings of many are most beautiful, and their habits are remarkable. The sabella, one of the most interesting of the tube-builders, may be found on rocks or shells in tubes of a parchment-like color built of sand and mud. From the end of the tube the worm extends a plumy crest of feather-like forms, which are the breathing-organs and are called gill-filaments. Each filament has two fringes of little tentacles extending along its length on the inner side, and these sensitive organs come into play when the tube is



AN EGG-CASE OF THE SKATE.

ment, the water is expelled through the other tube, and we see it rising slowly from the opening. If, however, the clam takes a fancy to contract

A SOFT CLAM BURIED IN THE MUD.
The siphon extended above and the
foot burrowing below.

built. The process is wonderful. Bending down with slow and graceful motion, the worm allows

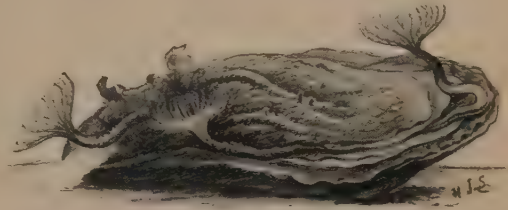
cohesive power. When the action ceases, it will be seen that the tube is slightly lengthened.

One of the most interesting members of the crab family is the queer and grotesque little "fiddler" which lives in burrows in the banks of



A CLAM PLACED IN A GLASS OF SEA-WATER.
Currents of water being watched through a magnifying-glass.

the fringes of the filaments to gather a portion of mud from the sea-bottom, when, fingering and molding it, the fringes carry it down the length of the filament to the bottom of the funnel. Here it is given into the charge of two leaf-like organs on the neck of the worm, which place this building-material on the edge of the tube and shape it there, while at the same time a mucous secretion is given off by the worm which gives the mud



THE WORMS SABELLA LIVING IN THEIR TUBES ON AN OYSTER.

The worm at the right is not yet inclosed in the tube. There are some old abandoned tubes on the upper part of the oyster-shell.

creeks and estuaries back of the beach. Into these burrows the crab retires in autumn and composes itself for a long winter sleep. The eye-stalks are then folded down into sockets beneath the shell, and the large claw rests closed and inert against the body, while the legs are folded up until the entire animal is snugly closed upon itself, and it remains in this dormant condition until the spring. Early in April the fiddlers awaken, and immediately attend to clearing out their burrows. The large claw is useless for eating, only the small one being available for this purpose. It is amusing to see the delicacy with which this little claw feels about and picks up the particles of vegetable matter and places them in the

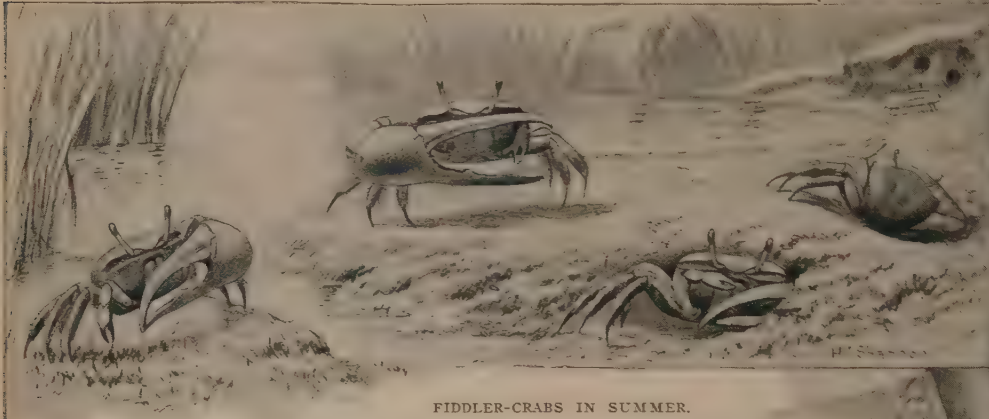


TWO BLUE CRABS FIGHTING.

Just in front of the crab coming toward us there is an anemone which has closed to protect itself. Expanded anemones are seen in the foreground at the left and on the rocks at the right. A hermit-crab and a shrimp are shown at the left.

mouth, while the eyes are all the time raised aloft on their stalks and apparently looking off into the distance. The female crabs have both

bundle of mooring-threads called the byssus. The mussel produces these



FIDDLER-CRABS IN SUMMER.

The one at the left is picking up food, while the one in the burrow is placing food in its mouth. At the extreme lower right a bank is shown as it appears in winter, cut through to show a crab hibernating in its burrow.

claws small and of equal size, so they are both used in feeding, and she can satisfy her hunger just twice as easily and quickly as the male. These fiddler-crabs also gather food and store it in their burrows for future use.

Another queer crab is the *Limulus polyphemus*, or horseshoe-crab. These crabs lay their eggs in the warm sand in summer, and in August the little ones hatch out in great numbers, so that in certain situations the shore is fairly alive with them. We may see them now, no larger than one's finger-nail, swimming actively about in the shallow water, or plowing the sand up before them with their queer little shovel-shaped heads. They soon retire to deep water and live there with their parents, either on the sea-bottom or half buried in the mud and sand.

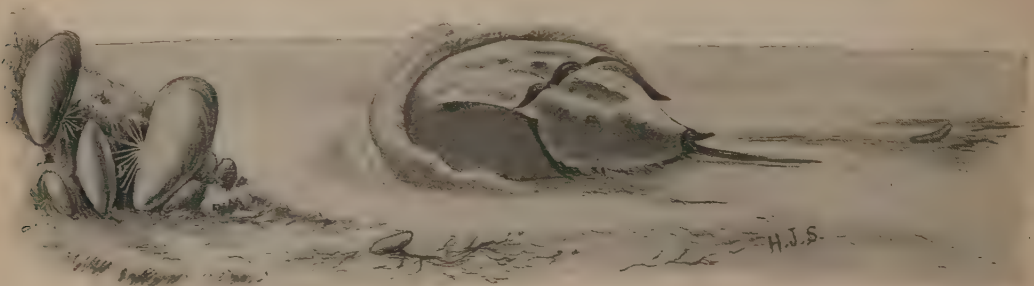
Great quantities of mussels are fastened all along banks and on the rocks. If we try to pull one away, we find it is securely fastened by a

threads at will when it finds a suitable situation; and although of apparent delicacy, these strands are very strong.

HOWARD J. SHANNON.

A MONSTER FISH

In this article we show a picture of a huge fish remarkable both on account of its size and its game qualities. It is known as the black sea-bass or California jewfish (*Stereolepis gigas*), and is found in moderate depths of the Pacific Ocean from the Farallones southward, being quite abundant in the kelp-beds about the islands off the coast. The one here shown was taken at Avalon, Santa Catalina Island, where anglers for large game-fish resort. The weight of the monster was four hundred and fifty-nine pounds. The fish is said to attain a weight of six hun-



A HORSESHOE-CRAB BURROWING ON THE BEACH.

At the left some mussels are attached to the bank by their anchoring-threads.



dred pounds or more. It feeds chiefly on other fishes, and, taken by hook and line, affords great sport for anglers. Heavy (25 ounce) $7\frac{1}{2}$ -foot rods of green-heart or split bamboo, large and well-constructed reels with a capacity of four hundred feet of No. 21 Irish-linen line, a 9-foot wire leader, and a 10-inch hook baited with several pounds of albacore, barracuda, or a live white-fish (*Caulolatilus*), are the tackle used by sportsmen. Rope, chain for leaders, and shark-hooks are used by the native hand-line or market fishermen.

The black sea-bass of California is one of the groupers, several of which grow to a weight of five hundred pounds or more (for example, the guasa, or spotted jewfish, and the black grouper).

Two notable specimens taken by rod and line weighed, one 419 and the other 384 pounds.

C. F. Holder tells us of a huge jewfish which he caught. It measured six feet in length and weighed three hundred pounds. He says:

"After we had beached the fish, a little fellow, who had been heard to say that he would like to ride a real jewfish, was placed astride the monster and was photographed."

WONDERFUL WORK BY SHELL-ANIMALS

ONE of the most wonderful things Mother Nature does is to teach her children how to accomplish things with means and appliances that seem entirely inadequate for the purpose. A bird will build an intricate and beautiful nest with no better tool than her beak (birds do not use their claws for this purpose); a caterpillar can shape a symmetrical cocoon, and bees the sharp-angled cells of their combs. These are familiar instances of this, but by no means as wonderful as those shown in the work of some sea-animals that live in shells.

A certain sea-shell, *Lima hians*, shown in the illustration snugly ensconced in a dainty little nest of pretty variegated, tiny shells and red coralline, not only swims about as freely as a butterfly flies—though, as far as its form is concerned,



"A LITTLE FELLOW WAS PLACED ASTRIDE THE MONSTER AND PHOTOGRAPHED."

a snuff-box would be apparently as well fitted to do so—but actually builds the nest that it lives in, spinning a sort of net which binds the parts together, and this in spite of the fact that it has no eyes.

Another shell, *Pholas*, accomplishes something more wonderful—though this seems scarcely possible—than the *Lima hians*, for it actually works

hard armor that is said to be renewed as soon as it is worn away. As may be conjectured, however, it would take a very long time to make any sensible impression on the hard gneiss or granite with such an instrument.

So naturalists are not all of one mind about the matter. The only certainty is that Mother Nature teaches the *Pholas* to do this marvelous thing with appliances that seem utterly inadequate to the task.

The *Pholas* is shown at the bottom of the illustration on this page, safe within its rocky "nest"; at the top, in the circle, are to be seen the *Limas*, fluttering about like moths in the dark. They are phosphorescent, however, and give out a light of their own, as do fireflies.

THE RED-WINGED SEA-ROBIN

I SUPPOSE the peculiarity which would be noticed first about the sea-robin, grunter, or gurnard, as he is variously called, would be his clumsy shape.

The head is large and deep in comparison with the body. One of our observing young folks, looking at him alive in his tank of the United States Fish Commission, Washington, would be apt to exclaim, "Oh, see, he has little hook-claws which help him crawl along!" Sure enough, just in front of the pectoral or side fins are three little, finger-like processes on each side, which are used to stir up weeds and sand, and to rake around among the pebbles and rout out the small animals upon which the sea-robin feeds in its native waters. While doing this it seems to be crawling along over the bottom by hooking these peculiar claws into the sand. Sea-robins feed on small crabs, fish, shrimps, and other diminutive ani-

mals, which they find in among the loose stones. In Europe all the gurnard family of fishes are eagerly sought, as they find a ready sale in the fish-market. They attain a length of two feet and a weight of eleven pounds. Our species of the sea-robin, a cousin to the European variety, is found on our northern coast, and is taken in great numbers in the pound-nets along Vineyard Sound, where they spawn in the summer.

"NESTS" BUILT BY SHELL-FISH.

Phosphorescent *Limas* "flying" through the water as butterflies through the air.

Pholas excavating burrows in rocks.

out nests or burrows for itself in the hardest sort of rocks, such as gneiss and granite. No one knows how this is done, for the material of the shell and of every part of the animal inside of the shell is, of course, much softer than the rocks into which it burrows. It is generally supposed that the creature works its way into the hard substances that it penetrates by means of what is called its foot, which is covered with a

They are much esteemed for the table, being one of the most delicate of the edible fishes. The flesh is firm, snow-white, and hard to distinguish from that of the kingfish. The American sea-robin is fifteen to eighteen inches long and weighs from one and one fourth to two pounds. When taken from the water they grunt quite loudly, and if placed on the ground give a little hop forward of a few inches, grunting as they do so. This grunting sound can be heard quite plainly if one is in a boat lying quietly in shallow water near where they are.

The head is sheathed with bony plates and armed with sharp points, which are rather hard to distinguish at first, as they lie quite flat against it. When caught they erect all their spines and inflict very painful wounds on those who try to handle them. The pectoral fins are a little more than half as long as the body, and may be extended like a fan when in use, or folded quite close together when on the bottom, thus giving them the name of "butterfly-fish."

The rays of the tail may also be much extended to look like a Japanese fan.

The color of this peculiar fish is a brownish yellow over the back and sides and cream-white below. The pectoral fins are deep orange-color with a blackish marking toward the tips, crossed all over with little dark brown lines and edged with light yellow-orange color. The lower jaw and sides are light orange-yellow; the eye is a beautiful turquoise-blue, edged with a vein of brassy yellow.

HARRY B. BRADFORD.

THE MUSSEL'S MUSCLE, AND HOW HE USES IT

How is it that a mussel can close its shell so forcibly? The muscles are two in number, one in each end of the shell. They extend straight across from one valve to the other. Thus the fibers act at no disadvantage. The muscles in the arm of a man are arranged at great disadvantage, power being sacrificed for amount and rapidity of motion.

You must, sometime, try to open the shell of a fresh-water mussel or a sea-clam. You will find one the size of your hand has great strength, although both his muscles may not be larger than

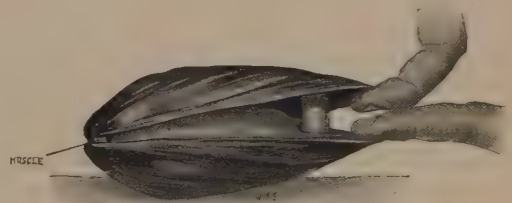


THE RED-WINGED SEA-ROBIN.

The "hook-claws" are placed quite close to the body when the fish moves very fast, and are thus hidden by the large pectoral fin. But when near the ground they are extended in anticipation of clutching the sand or stony bottom. The artist has represented the fish quite near the bottom, in which case the claws are shown in the drawing.

those of one of your fingers. We have often seen a boy pick up a mussel and insert his fingers before the shell was quite closed, thinking he could open it again. Few boys can succeed. They usually have hard pulling to get their fingers free. A big mussel can bite hard. Were it not that the edge of the shell, in big specimens, is smooth and thick, a boy might get his fingers cut to the bone.

One who knows how can open the shell. We will tell you. Insert your fingers and pull stead-



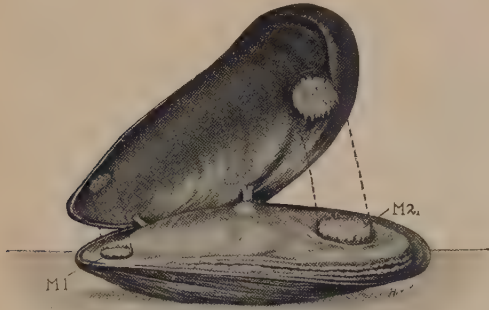
THE TWO MUSCLES OF THE MUSSEL.

Pulling against the fingers which are trying to separate the shell.

ily, not trying to open it at once, but simply to keep it from closing. The mussel's muscles will

soon get tired, and then you can open out the shell without difficulty.

You have one muscle to extend your arm and one to bend it. You have two muscles to open

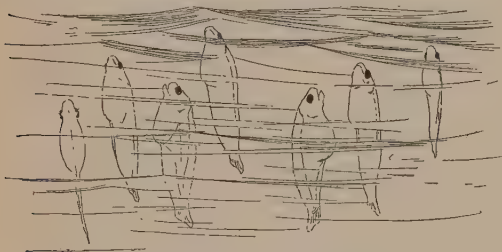


SHOWING THE MUSCLES (M^1 AND M^2) CUT ACROSS.
The shell now opens out easily.

your mouth and six to close it. The mussel, being inside of the shell, cannot open it by means of a muscle; but his two valves are joined by a great ligament so arranged that it will hold the shell open all the time. The shell is open unless the two big muscles are acting.

"AS FLAT AS A FLOUNDER"

FLOUNDERS are among the commonest, best known, and most remarkable of salt-water fishes. While most abundant in northern waters, they



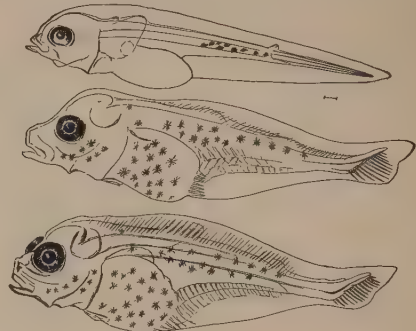
NEWLY HATCHED FLOUNDERS.

They are entirely transparent, except the eyes, and swim vertically, with the head toward the surface.

are found also in the temperate and tropical regions, and are so widely distributed that there is scarcely a seashore or bay anywhere in the world which has not one or more representatives of the flounder family. The largest and most important of the flounders is the halibut, which attains a weight of four hundred pounds. It is much sought by the fishermen of the United States, Canada, Great Britain, France, Norway, Japan, and other countries of the north temperate zone. The flounders are bottom-loving fishes, and pass most of their lives lying on one side,

either on or partly buried in sand or mud, at depths ranging from a few feet to several thousand feet. As the food of flounders must always be sought above them, and as their enemies always come from above, these fishes would have no use for an eye on their under side, hence both eyes are on one side of the head. The under surface of the body, being out of sight, has no marked color, while the upper surface is richly pigmented, the shade and pattern of coloration corresponding with the nature of the bottom on which the fishes may rest.

The expression "as flat as a flounder" has become proverbial, but it does not apply to very



THREE STAGES IN THE LIFE OF A YOUNG LEFT-SIDED FLOUNDER.

In the bottom figure the right eye is seen coming around the front of the head to take its place beside the left eye.

young flounders, which differ so much from the adult ones that they can hardly be recognized as belonging to the same family as their parents. Most boys and girls are familiar with full-grown flounders, but very few young people, and indeed few older people, know anything about the appearance of young flounders and the wonderful transformations they undergo. In spring and summer it is possible for young nature-students to secure specimens of newly hatched flounders by dragging a fine-mesh net on sunny days when the water is smooth. Such specimens may easily be kept alive in dishes of salt water, and examined from time to time with a low-power microscope.

The flounders begin life as do ordinary fishes. When they first emerge from the egg they swim vertically, with the head turned upward. Their bodies are symmetrical, and their eyes are on opposite sides of the head. Gradually the position of the body changes from vertical to horizontal, and the fish remain thus for some time, swimming like ordinary fishes; but while still very small there is foreshadowing of the bottom life they are destined for, and they enter upon a



THE YOUNG OF THE WINDOW-PANE FLOUNDER.

This is a left-sided species. In these figures the right eye has begun its passage across the forehead to the left side. The dark spot below the right eye in the upper figure is the left eye seen through the transparent head.

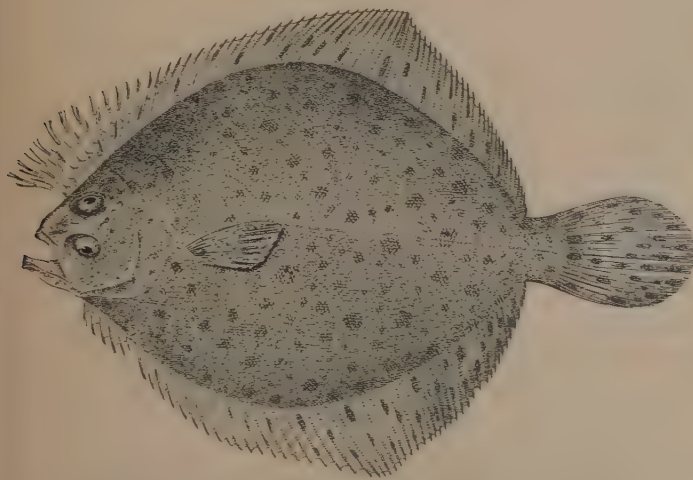
series of remarkable changes. The most striking of these changes is in the position of the eye. The eye of one side or the other slowly but steadily moves over to the opposite side of the head and takes a place beside the other eye. In some flounders the eye moves around the front of the head; in others it moves directly through the head. This shifting of the eye's position is accompanied by a change in the position of the body, which ceases to be upright and becomes more and more oblique. The side of the body from which the eye is moving gradually becomes inferior to the other, until by the time the change

of the eye is complete the fish swims with its blind side underneath, and this position is ever after maintained. The flounder then ceases its free-swimming habit and sinks to the bottom.

Some species of flounders are right-sided and others are left-sided. In the right-sided forms, the left eye moves to the right side, and the left side becomes undermost. In the left-sided species the opposite conditions prevail. It rarely happens that right-sided species have left-sided individuals, and vice versa. In a few species both right-sided and left-sided fish occur in about equal numbers.

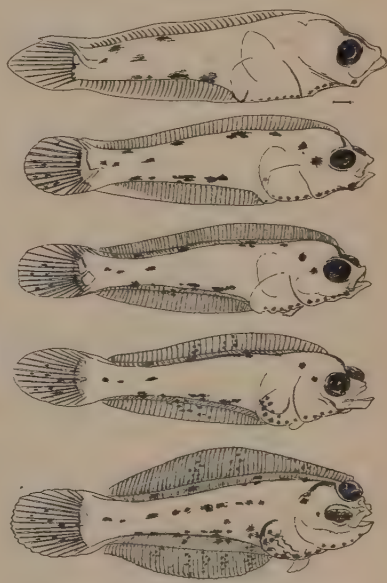
Soon after hatching, the flounder's color begins to appear in the form of small star-shaped masses of pigment on the body, head, and fins. These increase in number as the flounder grows, and finally run together and give the fish its peculiar pattern of coloration. The pigmentation of the under side begins to disappear soon after the eye changes its position, and when the bottom-living stage is reached no color remains on the blind side of the fish.

The flounder fishery is carried on chiefly during the winter and spring months, large quantities being taken. As a food-fish the winter flounder holds a very high rank; the flesh is white, firm, and of excellent flavor. Next to the halibut it is the most important flatfish of our Atlantic coast. This species has been more extensively propagated than any other member of the family. The United States Fish Commission obtains the



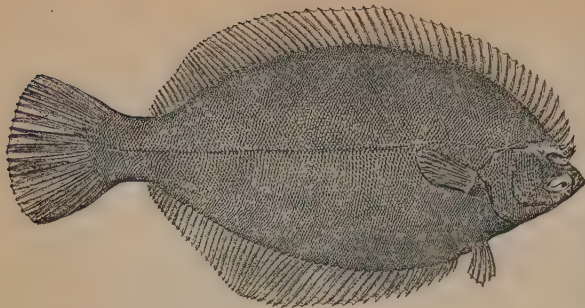
THE WINDOW-PANE FLOUNDER (*LOPHOPSETTA MACULATA*).

A typical left-sided flounder of the east coast of the United States. It is called "window-pane" and "daylight" by fishermen because it is exceedingly thin and transparent.



STAGES IN THE LIFE OF A YOUNG RIGHT-SIDED FLOUNDER.

Showing change in the position of the left eye.



THE WINTER FLOUNDER (*PSEUDOPLEURONECTES AMERICANUS*).

A typical right-sided flounder of the Atlantic coast of the United States, and an important food-fish in New England and New York.

eggs at Woods Hole, where its propagation fills in the time between the taking of the cod on the one hand and the lobster on the other.

"SLAP" AND "SNAP"

"SLAP" was a frog. We called him Slap because when he jumped and landed on the hard floor, as he was in the habit of doing whenever he could get out of the pond, it sounded like a slap of mud on a stone.

His "slaps" were always unexpected in both time and place. Once Slap's slap was a crash. That was when he landed on the edge of a projecting sheet of glass over an aquarium. He went down; so did the glass. One difference was that Slap held together.

"Snap" was short for snapping-turtle. He had a way of making things short, especially a small stick that the young folks were fond of putting in his mouth, although his experiments along this line were not confined to sticks. One day he tackled a bullfrog and shortened him by a leg, and incidentally shortened his life.

You see that Snap was rather a dangerous fellow. So we cautioned the young folks who played by the pond-side and watched the antics of frogs, turtles, fish, and water-insects.

Slap was an explorer. He tried to find the north pole. At any rate, he climbed up the wire netting of a north window and jumped on a pruning-pole laid across some braces just under the roof. It took him as much as five minutes to find the pole. The pole turned, and the explorer returned to the floor in less than a second.

Snap was a stay-at-home. He was perfectly contented to lie for many hours in the mud and wait for a fish to swim within reach. To such a fish he extended a cordial invitation to come in and visit him. Whether or not the invitation was accepted in that form, I am not sure. I know that a fish was soon missing.

Snap was a great racer, although from his actions and appearance you never would have surmised it. One day, however, he showed what he could do in that way. He had been placed on a high table to be photographed. This table extended in front of a row of cage doors, and was attached to the wall just under them. One of these doors, through some one's neglect, had not been fastened, so "Pete," the white rabbit, came out—just to see what was going on, I suppose. He was disappointed in that—he saw what was going off. Just then my attention was called to something in another part of the room, and as I turned to attend to it the race began, both Pete and Snap making for the edge of the table. Snap came in, or rather down, ahead—at first on his head. He beat by several feet—two feet to the edge of the table, three feet down, and then four feet up—all four clawing in the air. Pete, peering cautiously over the edge, showed no disappointment because he had failed to arrive first. In fact, I have been a little in doubt as to what he did show, or indeed as to whether he ever fully appreciated the situation. I am inclined to believe that he did not. If he knew what he had escaped, he seemed unmoved by the thought.

Slap and Snap, though totally unlike in movements and disposition, were very friendly. My assistant said they were the best friends he ever saw. I asked him why he thought so, and he told me he supposed it was because they were always in the same "swim."

Slap and Snap were wise, too; they were philosophers in the art of living. At any rate, I gave them credit for that. Perhaps you would have said Slap mistook the turtle for an island when he jumped on his back and took a ride around the miniature pond. But I was charitable. I gave him the full benefit of the doubt, and said: "Slap is a genius. There he is, taking a free ride, apparently saying, 'This is the art of taking life easily. What's the use of swimming when you can get some one else to do it for you?'"

And Snap, I fancied, said: "Might as well make the most of the burdens of life, and carry them as gracefully, humbly, and uncomplainingly as possible."

Poor Slap and Snap! Where are they now? Perhaps in the mud of the pond to which we carried them in late autumn; for you must know that this pond to which I have been referring as their summer home was a six-foot tank under the trap-doors of our nature-playhouse.

And down there in the mud, if Slap and Snap ever dream, I hope they are dreaming of the young folks to whom they gave many a laugh by their interesting antics last summer.

WONDERS OF INSECT LIFE

JEWELS ON SPIDER-WEBS

ON dewy mornings a little careful observation will reveal on various small objects many beautiful forms of dew that are commonly overlooked. Nature seems often to put her most



A SPIDER-WEB WITHOUT DEW.

exquisite work in her smallest things. This is especially true of dew formations. To the observant eye the large drops of water in a gentle rain are seen to cling to many objects, as, for example, twigs, wires, stretched cords, and clothes-lines. Much more dainty, yet of similar form, are the dewdrops on the finest parts of plants and leaves. Perhaps the smallest object on which these tiny, pearl-like formations may be observed is a thread of a spider-web. Here the drops are so small that they do not elongate, but keep a beautiful spherical form.

The web is so fragile, however, that it is difficult to photograph these drops. Mr. Wilson A. Bentley, who took the photographs here shown, sets up three panes of glass around the web and places another pane on top. This makes a temporary gallery in which there are no currents of air to shake the delicate web. To secure a black

background he uses a large pail painted black on the inside, and placed behind the "box" of glass. A box or pail thus blackened is better than a sheet of black cardboard or cloth, because the light sometimes strikes a black flat surface at such an angle that it photographs nearly white.

To secure a section of the dew-laden web, he bends a wire into a loop shaped like a tennis-racket, leaving one end to project as a handle, and smears the loop with Canada balsam or with some other sticky substance.

Find a web so suspended that you can place the wire loop beneath it. Then press gently upward until you detach and secure the whole or a part of it on the wire. Thrust the stem of the loop to a sufficient depth into the ground within the glass gallery, and arrange it properly as to height and position.

Center and focus the object by moving the camera about on the ground or on a board laid



A SECTION OF WEB WITH DEWDROPS.

on the ground. Place a cap on the lens. Spread the focusing-cloth from the camera to the edge of the glass inclosure. Now lift the cover from the glass inclosure, remove the cap, place the

glass cover on again, and expose for from ten to fifty seconds or more, according to circumstances. It is best to use the lens well stopped down.

Many dew-laden objects may be photographed in their natural position, without removal to the



AN ARRANGEMENT OF DEWDROPS AND WEB
SUGGESTING JEWELRY.

glass inclosure, provided the air is very still and the objects are so situated as to permit the placing of the blackened pail or other suitable background behind them. But when this is impossible, or when the breezes blow, they may be clipped off and placed within a wooden vise, or



A NEARER VIEW FOR BETTER DETAIL.

other firm holder, within the glass inclosure, and there photographed.

Dew photography should be a delightful pursuit the world over, on account of the great num-

ber of different forms of plants and other objects that each country affords, every one with its own charming way of collecting drops.

A WONDERFUL MOVING VINE

NEAR the bank of the Guadalupe River, I saw something green upon the ground, and, hurrying forward, found a lovely vine with leaves smaller



THE WONDERFUL MOVING "VINE."

than those of the smilax, of a pale, tender green. The vine had its root about five feet from the trunk of a towering cottonwood-tree, and spread out on the ground four or five inches wide, becoming a little narrower as it approached the tree. I could see no stems nor tendrils, so thick was the growth; and as I drew close to the tree I saw that the vine branched just above the ground and went climbing up the great trunk and the branches. It grew more and more slen-

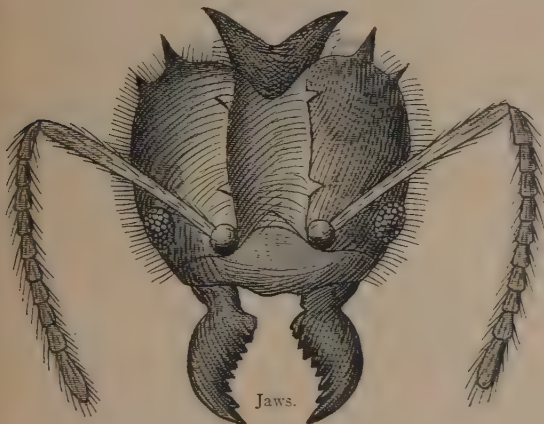
der, until, far up, I could distinguish only a threadlike line of green.

As I stood intently watching the delicate, graceful vine, I became aware that it was per-



ANTS CUTTING OFF LEAVES OF THE COTTONWOOD.

vaded by a curious, tremulous motion. Then I saw that the individual leaves were not stationary. Picking up a twig from the ground, I touched one of the leaves and found to my amazement that there was a brown ant under it about as long as my little finger-nail. Each leaf



THE HEAD OF A LEAF-CUTTING ANT.

To show the sharp, saw-like jaws.

was held in the mandibles of an ant in such a way as to conceal the body of the insect, and the ants were coming down the tree. The discovery came upon me with a shock. I had stumbled on

a nest of umbrella-ants. Books had told me that such ants were found in the tropics, where they carried bits of leaves over their heads as if to protect themselves from the sun; but here, on the banks of a Texas river, I had found a colony of them, shading themselves where there was no sun, and completely hidden by their covering of green.

Charmed at the sight, I turned back to call my companions, who were fishing in the river. Within a few yards, I met my husband coming to look for me. He was even more excited over the phenomenon than I was, and shouted for the others to come quickly. On investigation we found that the spot where the vine seemed to have its root was really the opening of the ant-nest. The tiny creatures had by some instinct learned that the topmost branches of the cottonwood had put out their first small leaves. They had climbed the immense distance and had cut off and brought down their leaves—to feed their young ones, we supposed. The ants which issued empty-jawed from the nest made a long circuit to the farther side of the tree and climbed up where they would not interfere with the leaf-bearing thousands coming down.

HOW THE HORSE-FLY BITES

It is not unusual, while riding along a wooded country road in the summer, to observe the annoyance that the horse is forced to bear by reason of the swarms of small flies that attack his head and neck, and it is nearly as common to witness the assaults of another and larger fly, which, although it does not occur so abundantly, is numerous enough to destroy the pleasure of the ride, and to keep the horse in a constant state of restlessness and of nervous excitement. These larger flies have the habit of making a sudden dash under the horse's head, or of striking him in some other part not reached by the sweep of his tail, the attacks, if at all frequent, making the animal wild with pain.

Being curious to learn how these insects manage to draw the enormous amount of blood that follows their bites, I captured several of the larger forms, and, on reaching my home, dissected the mouth-parts and laid the organs on a slide, so that they might be examined by the microscope. The photograph herewith presented gives as correct a view of these piercing instruments as may be had through a good objective, for the picture not only exhibits all the mouth-parts, but also gives a distinct view of the two compound eyes.

It might be supposed that to obtain the blood these insects employ as simple a process as that used by the surgeon, but, instead of his single lancet, these flies, as well as other insects that live on the blood of the higher animals, are provided with an outfit of instruments consisting of no fewer than five distinct pieces, all of which are carried under the chin, and, when not in use, are carefully inclosed within an elastic sheath.

The five parts referred to, consist, as shown in the figures, of the blood-sucking tube, marked A, the central piece; two knives, B, B; and the two



THE MAGNIFIED VIEW OF THE TONGUE OF A HORSE-FLY.

hooked pieces, C, C. These are the only organs directly employed to draw the blood, but, in addition to them, there are a pair of feelers, or palpi (E, E), used to locate the best point of attack.

All these, except the palpi, are closed when not in use, and are included within the proboscis, D, which has a slot along the lower side, through which they are protruded. This proboscis, by the way, is similar to that of many other flies, and when blood is not available, may be used to take other nutritious liquids.

It will be observed that, in the process of "biting" or of drawing blood, the central piece of the sucking tube is too blunt to be forced through or even into the tough skin until a cut is made to receive it; so the two knives, B, B, with extremely sharp points and keen edges, are ready to perform this office. But when the cut has been made a little leverage is required to hold the pumping tube in place, so the other two pieces, C, C, which under a high magnifying power are seen to be lined with sharp teeth pointing backward, are inserted, and hold the parts firmly, while the central tube is forced into the cut.

It may be well to remark that only the females among the horse-flies, mosquitos, and similar insects, have mouth-parts adapted to draw blood.

The males have the usual proboscis, but not the blood-taking tools. Unlike the mosquitos, none of the horse-flies of this country insert poison into the wound, although some occasionally bite human beings.

THE WONDERFUL SILKWORM

If a boy had money enough, he would like to buy his mother, or his sister, a silk dress for her birthday. Much pleased she would be to have it. But if he said to her: "Here is a caterpillar gown for you," she would be horrified and call him a dreadful boy. Of course, a silk dress is not really a caterpillar dress, for that would mean that the dress was made of caterpillars. But though this is not the case, the material, if it be pure silk, comes entirely from the caterpillar, only we call the caterpillar in question a silkworm. That is merely a way we have. We call the silk-yielding caterpillar a silkworm, and we call the light-giving beetle a glowworm. Many things go by wrong names in common speech, and the result is that, when we study natural history, we are surprised to discover the true nature of the things we have so long misnamed.

The material of the silk dresses that our mothers and sisters are fortunate enough to have, is made by a very ordinary-looking, big, fat caterpillar, and boys who keep caterpillars of this sort may, if they like, become silk merchants on a small scale. The silkworm is as much dependent upon man as is the canary in its cage. If all the tame silkworms in captivity were turned loose, the bulk of them would die. They depend upon us for their living, and we depend upon them for our silk. We can make lovely scents and sweets from coal-tar; we can make all sorts of things in the laboratory of the chemist, but not all the wisdom of man can make a piece of silk. How came man, then, to have these wonderful insects to work for him, and how came they to depend upon man for their safety? It is a wonderful story, and takes us back thousands of years.

It was those wonderful people, the Chinese, who first discovered the use of silk. They learned that it could be woven into material for dresses, and they learned how to get it from the silkworm. They found that the caterpillar or the silkworm could be kept alive in captivity; that it would thrive as a prisoner, if kept clean and fed on mulberry-leaves, quite as well as if it were at liberty. So they kept the caterpillars, and when these turned into moths, they kept the eggs that they laid, and when the caterpillars spun cocoons of silk in which to live, they took a cer-

tain number of the cocoons and unwound the silk of which they were composed, and made the silk into dresses. What the Chinese were doing with caterpillars nearly five thousand years ago, the people in many countries are doing to-day, and all for the same purpose, that men and women may have silk to wear or to use for the thousand and one purposes for which this beautiful fabric is so much sought. Let us see what this wonderful process of nature is that gives the world its silk.

FORTY THOUSAND EGGS THAT WEIGH ONLY AN OUNCE

WE will suppose that we are setting up for ourselves as keepers of silkworms. The eggs—the only things that we need—can be bought, and we can set to work to gather silk this very summer. It is better fun even than keeping ants, for here we can see all that happens in the process. With how many eggs shall we start? A pound? No, nor an ounce. They are so light that there are about 40,000 eggs of the silk-moth to the ounce, or about 100 to a grain. Of course, we must have a proper place—a greenhouse is a good place—in which to keep the eggs, where we can be sure that the temperature will not fall below 62 degrees, nor rise higher than about 80 degrees. The heat may be increased as the time for hatching draws near, but it must never be more than 80 degrees. As a matter of fact, the lower the temperature, so long as it is not lower than 62 degrees, the stronger and better the caterpillars will be.

Thousands of poor people, however, have bred silkworms who could never afford a greenhouse. How did they manage? Many of them have put the eggs carefully in a bag and carried the bag tied round their necks so that the warmth of their bodies might hatch the eggs.

WHEN AND HOW TO HATCH THE SILKWORM EGGS

WITH ordinary care there is no difficulty about hatching the eggs, but we must be ready for the day when they do hatch. First of all, we must be sure to have a supply of leaves of the mulberry-tree ready. It is of no use our hatching the eggs if this tree is not in leaf. The caterpillars would eat lettuce, but they would not be nearly so fine, nor would their silk be worth much, after a diet of this sort. The next thing is to see that we have ready a very thin card, or piece of paper, pierced by little holes, which may rest on a ledge in the box, over the eggs. The

little caterpillars, as soon as they are hatched, will see the light through these holes, and will crawl toward the light through them. In doing so, they will scrape off the shells clinging to them, and so escape all risk of being killed by being unable to free themselves from the shells. The caterpillar of other moths, as soon as he is born, makes a meal of his shell, but the silkworm needs this little help.

Now comes the first enjoyment of silkworm rearing. We can have a great many in a single big cardboard box, but we must be careful that this does not become crowded, or there will be trouble when the time for cocoon-spinning comes. Better have three or four big boxes, like those in which the tailor sends home clothes, than that the silkworms should suffer for lack of sufficient space. It is a great convenience that we may safely leave the box open. We could not do this with any other caterpillars, for they would escape.

THE LITTLE SILKWORMS THAT WILL EAT A FOREST OF LEAVES

NOT so the silkworm. It is as happy as can be in a box without a lid, provided it has plenty of food, and that the box is perfectly clean. Keep down the heat to as near 62 degrees as possible, and the silkworms will grow big and strong. They eat a surprising quantity of mulberry-leaves.

We are not going to have a whole ounce of eggs, with 40,000 silkworms hatching out; but, in order that we may get an idea of the appetites of these insects, we will suppose for a moment that we have this number. During the eight weeks that they live in the caterpillar stage, the 40,000 silkworms will require 1362 pounds of mulberry-leaves. Of this quantity, about 590 pounds will be wasted, for we take out all dry and stale leaves. But there remain 772 pounds to account for. That amount the caterpillars actually eat. We have to exercise care in the feeding; to distribute the food evenly, so that the caterpillars shall not have to struggle and fight for their meals. A good way is to cut up the leaves small, as this makes the distributing easier. The pace at which the caterpillars grow is surprising. Like other caterpillars, they have to molt—that is, to cast their skin. The skin in which they are born does not last all their lives.

HOW THE LITTLE SILKWORM CHANGES ITS SKIN AND GROWS BIG

WHEN they are about six days old they cease to feed. The skin splits down the back and the

caterpillar crawls wearily forth, bearing his new skin about him. His appetite returns, and he eats more heartily than ever. He grows rapidly when the new skin is still soft. But, after a few more days, another new skin is required, and after that a third, and finally the fourth.

Each molting-time is a period of serious trial for the silkworms, and many die during its progress. Once the last molt is over, however, the caterpillar eats away as if it knew that its days for feeding were numbered. By this time it has become one of the biggest of all our caterpillars. Whereas it was at birth only a speck, weighing the hundredth part of a grain, it has now increased its weight to about 95 grains, and its length to three inches or thereabouts, which is a very rapid growth for two months. Now comes the most important time of the caterpillar's life. It has to become a chrysalis, and it is in order that it may safely pass through the chrysalis stage that it spins the famous silk.

All the time that the silkworm has been growing up, it has been forming and filling two large vessels, or sacs, that run along the sides of its body. In these two sacs is stored a sticky fluid. If we saw it in its natural state—that is to say, the state in which it is while still in the body of the caterpillar—we should not have the least idea as to what it was.

THE STICKY STREAM THAT BECOMES A STRAND OF GLOSSY SILK

THAT sticky stuff in the body of the caterpillar is to become the marvelous silk which makes the insect so valuable. When it is about to spin, as we call it, the caterpillar ceases to eat anything. As we watch, we see two tiny streams issue from its lower lip. That is the silk issuing from the spinnerets, or seripositors. It is as well that we should know the names, so that we may not have to puzzle when we meet them elsewhere. We must remember, too, the scientific name of the silkworm. It is the *Bombyx mori*. Well, then, the *Bombyx mori* begins to spin its cocoon by producing two tiny streams of silk from its spinnerets, or seripositors. The sticky fluid, if we force it from the body of the silkworm, becomes hard at once; but, manipulated by the silkworm, it is drawn out into beautifully fine strands of silk. The two strands are joined together by the silkworm to form one thread, and it is only by the aid of the microscope that we are able to discover that there are two in the thread. With this material, the silkworm weaves itself the loveliest house of silk.

The work may take two, three, four, or even

five days. Little by little, the silkworm builds up this castle of silk, weaving it so perfectly that at last the worm is entirely shut in and quite invisible. All the time that it is thus building, the silkworm works its head round and round in a regular order, never wearying. And all the time the silk never fails.

A DAINTY GLOBE OF SILK THAT LOOKS LIKE A FAIRY EGG

THE silkworm, at the beginning of the task, weighs over 90 grains. When the labor is ended, the silkworm, with its cocoon, weighs only about 50 grains. And there it is in a lovely globe of tightly woven silk, looking like some fairy pigeon's egg. The cocoon may be either white or pale yellow. Having watched the spinning, we realize why we ought to be careful that the silkworms have plenty of space. If they are at all cramped, two will spin together only one cocoon, and this will be useless.

If we leave the cocoons alone, there will come forth, in about fifteen days or three weeks, a pretty moth from each. The average length of the moths is about an inch, but the males are slightly smaller than the females. They can be kept on a cloth. They eat very little, and sometimes even nothing at all. The females lay 500 or more eggs, and then die, and the males do not live long after them. Their whole lives as moths last but a few days. In that time, they never try to fly away. The females cannot fly at all; the males have just enough power in their wings to steady themselves in descending, but they cannot possibly fly upward.

In this, we see the result of thousands of years of care and attention on the part of man. The *Bombyx mori* has always been the one species common everywhere as man's silk producer. Certainly, there are others in captivity in China and Japan, but they are not of much importance. In Europe people have never been able to do much with them. There are wild silkworms, too, but their silk is of little use to man, so there has been no attempt to cultivate them. Those that have been allowed to remain wild can fly about as well as any other moths. Only those that have been cared for by man have given up the power to fly. If they could, they would fly away, and we should never know where to look for their silk.

So far, we have traced the silkworm from the egg to the caterpillar, and from the caterpillar to the moth. What of the silk, of which we have talked so much? Here we come face to face

with a little tragedy. Every silk dress means the death of thousands of silkworms.

WHY THE SILKWORM MUST DIE IN ORDER TO GIVE US SILK

THAT sounds dreadful, but it is not so in reality. The life of the silkworm, as a silkworm, is ended when the insect has reached the chrysalis stage. It is then in a state of torpor, and can have no sense of feeling, unless time and care are given to rousing its sleeping energies to a sort of wakefulness. That is not done. When the cocoons are all ready, we have to decide how many moths we want to renew our supplies of eggs. We take away those for the nursery. The others we want for silk.

These we plunge into scalding water. Manufacturers steam them, or submit them to a high dry heat. This kills the chrysalis. The reason why this has to be done is, that if life remained in the chrysalis, the latter would turn into a moth, and would then form an opening at one end of the cocoon out of which to creep, so spoiling the cocoon.

The next step is to wind the silk on to reels. To do this, the cocoon has first to be softened in warm water of from 75 to 85 degrees. The water dissolves the gum that binds the silk threads together. A neat-handed girl then twirls the cocoons about with a light brush, that catches the loose ends and causes them gradually to unwind. All that we have to do is to undo the work that the caterpillar did. But the silk is far too fine to be wound in this state. In the thinnest part, the silk is so fine that 1000 strands of it, laid side by side, would cover only an inch, while, in the thickest part, from 600 to 700 strands would be required to make up an inch in thickness.

SOMETHING THAT THE WISEST MAN CAN DO NO BETTER THAN A BOY

So, when the ends of the silk are discovered, the operator joins four or five together, passes them through a fine eye of glass, or polished metal, in a winding machine, and, letting the cocoons remain in the water, winds away until all the silk that can be used is wound out from each cocoon. The silk is wound on to a big wheel, and care has to be taken to see that the strands do not stick together. In Eastern lands and in some parts of Europe they use machinery so simple that a boy could make it; but in big factories they have much improved on this. Still, the principle is everywhere the same, and

at this stage the wisest man in the world could do no better than any boy or girl who has had a little experience with the winding.

Once the silk is freed from the cocoon and wound on wheels, or whatever they may be, it is ready for the manufacturer. Many processes follow. The silk has to be freed from all the gum remaining on it, for at present it has no luster such as we expect silk to show. It has to be cleaned by boiling, to be scoured, and purified by acids. That is one way. Another is to let the silk begin its own purification by a process of fermentation, which means the shutting up of the uncleaned silk in tanks containing soapy water, in which the silk may lie for weeks. Then follow all sorts of washings, and finally drying.

HOW TANGLED SILK IS COMBED STRAIGHT BY A MACHINE

THEN we have the silk clean, but terribly entangled. Wonderful machinery combs out the tangle, and makes all the strands of silk straight, and smooth, and even. Finally, the silk is ready to be made up into dress-materials, or into whatever may be required, just as if it were wool or cotton. A garment of pure silk lasts a very long time, for there are few materials that wear better. Unfortunately, some manufacturers have discovered a way of adulterating it while the cleaning process is being carried out. They add salts of metals that are absorbed by the silk. This adds weight to the silk, and makes it appear a fine heavy fabric. But silk made by such dishonest methods soon rots. It is this adulteration that makes silk "cut" so readily, and makes a silk garment, or silk umbrella, become full of slits even when it is not much used.

HOW SOME STOLEN EGGS GAVE EUROPE SILK FOR 1300 YEARS

It is very wonderful to think that all the millions of silkworms that for 1300 years produced the silk upon which the whole of Europe mainly depended came from the batch of eggs stolen by two monks from China. So, however, it was. The art of making silk began, as we have seen, in China. The Chinese guarded their secret as closely as they could. They thought it good that their people should know how to make silk, but they did not want people in other countries to know how to do it. If other people wanted silk, they must buy it of the Chinese, not make it for themselves. They sold a good deal to Rome, for Rome in all her glory could not produce silk for

herself. This state of things lasted until 550 years after the birth of Christ. Then the wise Emperor Justinian, who ruled in Constantinople, saw how important the silk trade was, and determined that he would create a trade in silk for the Roman Empire.

Two Persian monks, who had long lived in China, told him that they had seen the whole process of rearing the silkworms, and the manner of treating the silk. So he sent them secretly to China to get him some eggs of the silk moth. They walked all the way from Constantinople to China, and they walked back again, but they brought with them some of the precious eggs.

THE SILKWORM'S EGGS THAT CAME TO EUROPE IN A BAMBOO STICK

It would have cost them their lives, had the purpose of their visit been known. They knew this, and were very careful. They got a supply of eggs of the silk-moth, hid them in a hollow bamboo, and then carried them to Constantinople and presented them to the Roman Emperor, who ruled in what is now the capital of Turkey. The Emperor was delighted. The eggs were hatched, and there appeared, for the first time in history, a number of silkworms in Europe. From each female moth he would get 500 or more silkworms, and from these in turn there would be another great increase. The monks had brought him, in the little bamboo nest of eggs, the richest goldmine that they could have given him.

The Emperor caused a silk factory to be set up in his royal palace. Only those whom he appointed—trusty women, who worked under the direction of the monks—were allowed to manufacture silk. But, in course of time, the eggs of the silk-moths were carried to other countries. In Italy and France many towns became famous for their silk manufactures. Frenchmen, persecuted on account of their religion, fled to England, and took with them the secret of manufacturing silk. That secret gave vast riches to England, though she had to buy raw silk from France and Italy.

VAST SUMS LOST THROUGH A DISEASE AMONG THE SILKWORMS

ENGLISH kings tried by every means in their power to get the cultivation of the silkworm taken up in their colonies, but it was never successful. Still, the manufacture of silk into articles of use became very important to the home country. It was still more important to Europe.

We may gain some idea of its importance from what happened when a terrible disease broke out among the silkworms of Italy and France during the second half of the nineteenth century. In spite of the disease, there were always some healthy caterpillars producing silk, and the trade never came to a standstill; but the damage done to that part of the trade which failed robbed France and Italy, in only thirteen years, of \$600,000,000.

It was only then, after all those centuries, that Europe had to send again to the East for more eggs of the silk-moth. During 1300 years Europe had been stocked with its millions and billions of silkworms from the descendants of those silkworms which came from the eggs carried away in a little bamboo by the two monks at the command of Emperor Justinian.

THE "LOBSTER" ON THE HOUSE-FLY

"THE other day I saw the queerest thing that I have ever seen in all my life," said a lady. "I was swinging leisurely in my hammock on the veranda when a fly with something dangling from its leg alighted on the railing. I stopped swinging and examined it. The fly was the ordinary house kind, but on its leg was a little, red, lobster-like creature."

It was a chelifer, and this special one was taking a ride at the expense of the fly. Although the little crab-like creature can walk backward as rapidly as forward, it not rarely wants to move faster or to transfer itself to another locality, when, by seizing the leg of an unsuspecting fly, it accomplishes its purpose.

Chelifers are said to be cousins to the spiders, scorpions, and daddy-long-legs on account of their structure, which is of interest to the naturalist. They are found under fallen leaves, under loose bark on dead trees, and one species occurs in houses almost everywhere throughout the world. They feed on tiny insects or mites which they capture by means of their large claws. The mother chelifer lays a number of small round eggs which she carries in a cluster attached to her lower surface until they hatch, when the young ones take care of themselves. Those living under bark make a tiny nest of bits of the wood, there shedding their skin, and passing the winter. They are perfectly harmless. They have no poison-glands and can neither bite nor sting.

THE FAMOUS LEAF-INSECT

WE all know how the wings of the katydids, and of some other insects, closely resemble the green

leaves among which the creatures are found. The walking-stick insect is like the green twigs on which it is found, and the roadside grasshopper cannot easily be told from the sand on which it alights.

Even a very little careful observation will find many such deceptions, which are of great interest to the young folks as well as to the learned grown-up people.

One of the most interesting examples of protective resemblance is the green-leaf insect (*Phyllium*), which is found in South America.



THE LEAF-INSECT.

Not only the wings, but body, legs, head, and even antennæ are leaf-like, of a bright green color. The markings of the wings appear to be leaf veins, and there are often small yellowish places in near imitation of decaying, stained, or fungus-covered spots on the leaves.

The accompanying illustration was photographed directly from one of these very wonderful insects.

Protective resemblance is not limited to such striking examples as this leaf-insect. Very many forms, large and small, of animal life are somewhat or wholly hidden by resembling the surroundings.

AN "OUT-OF-DATE" BUTTERFLY

If any of our young readers who like to go butterfly-chasing had been in South America in the year 1898, or some of our older friends had been there in 1889 and found the *Callicore cly-*



THE CALlicORE CLYMENA BUTTERFLY.

mena, they might have thought that the butterfly not only came from the chrysalis that year, but had taken to wearing a date, so that all naturalists might be sure from at least one wing that there was no mistake about the year in which it appears.

The dark lines form very distinctly the figures 89 on one wing and 98 on the other. Of course this is merely an interesting coincidence, without purpose or benefit as to dating; but some one, finding this *Callicore* in 1900, was led to exclaim, "Why, that butterfly is out of date!" But nobody could say whether it belonged to past or future '89's or '98's.

THE FIRECRACKER BUTTERFLY

If you have ever chased a butterfly, you know how well it is fitted to escape from its enemies by swift flight and skill in dodging. Just as you dash the net in full confidence of capture, you are surprised to see the insect far away in the field, or high in air, perhaps among the topmost branches of a tree, if you are butterfly-hunting in or at the edge of a forest.

A butterfly in South America, known to the naturalists as the *Ageronia*, makes a loud snapping noise when flying, so that we may well call it the firecracker butterfly. It pop-pops and snap-snaps in quite a startling manner as it flies here and there, and thus is not only able to get away from its enemies, but to frighten them away. Apparently the butterfly is noisy the greater part of the time, not so much for protection as for enjoyment in the popping, like a boy on Fourth of July with firecrackers.

You see, the closer and more extensively we study even the smaller members of the animal

kingdom, the more we find that "one touch of nature makes the whole world kin," and that the birds, butterflies, insects, etc., seem in some respects very much like human beings.



THE AGERONIA BUTTERFLY, THAT MAKES A SNAPPING NOISE LIKE A SMALL FIRECRACKER.

Discovering all these queer habits and traits of our little friends in the fields and forests makes the study of nature so intensely interesting.

SOME INSECT FOES

FEW of us imagine how important a part in the history of the world little insects play. Next to the poisonous snakes, they are really more to be dreaded than any other form of animal life. There is nothing else living that does so much damage to property. A lion or a tiger is more terrible to face than a mosquito, but the innocent-looking mosquito may cause death as surely as the fearful man-eater. Animals are big and comparatively few; insects are little, but their numbers are great, they are more than men can count, and the insects are not discovered until their damage is done.

How a plague of insects begins, it is not always easy to say. But we know how one began, and we may get an idea from that as to what happens in other parts. Until after the middle of the last century, the gypsy-moth was unknown in Massachusetts. Then an unfortunate thing happened. A French scientist was performing experiments in his laboratory with the window open, when a gust of wind carried out into the garden a few eggs of the gypsy-moth that had been sent to him at his Massachusetts home.

Those few eggs hatched, and the caterpillars became moths and laid many more eggs. So ter-

ribly did they increase that within a few years the gypsy-moths had spread over an area of 220 miles. Men tried in vain to fight against the plague. The caterpillars swarmed in the trees and ate them bare, as if a fire had swept over the land. Over 40,000,000 trees were raided again and again in this way. The State spent as much as \$90,000 a year for many years in succession, but still the plague continues, and still Massachusetts is robbed of much wealth by this pest.

The Colorado beetle is another dreaded enemy of the farmer. It is a rather handsome little beetle with its orange-colored, black-spotted coat, but it completely ruins the potato-crop wherever it gets a hold. Until recent times it existed only on wild crops, but then it got among the cultivated potatoes of Colorado. The mother beetle lays hundreds of eggs on the leaves of the potato-plant. The young ones hatch very quickly and lay eggs in turn, and then the young ones from these lay eggs—all this in one summer. During the winter they go to sleep in the ground, but they wake up in the spring, and attack the plants so that in some parts the potato-crops are completely destroyed. Any person found with living specimens in his possession is heavily fined.

Then there is the cuckoo-spit, or froth-fly, or frog-hopper, or frog-spit—it has all these names in different places. It is the insect that lives on stems of grass and many other growths. There are many varieties of it. It sucks the juice of the plant or growth upon which it lives, and forms a dwelling of froth, supposed by many to be little bubbles blown by the cuckoo. If we remove the froth we find a surprising little animal inside, a yellowish-green insect with long hind legs, with which it can hop like a frog. A little girl discovered one of these insects by making the sun shine through a magnifying-glass upon the froth. Out pounced the froth-fly, looking as surprised and angry as an insect can look.

Now, the frog-hopper serves to introduce us to one of his most dangerous relatives, the cicada, which, though known in Europe, is most deadly in America. Here we call it the seventeen-year locust. This title we give it because it appears as a pest once every seventeen years. What happens is this: The male flies of the perfect cicada die soon after their wedding day; but the female fly lays about 500 eggs in the twigs of the tree upon which it settles, and then dies. But before it dies it inflicts terrible damage upon the tree. The eggs lie in the warmth and hatch, and the grubs, as soon as they are born, fall to the ground, and make their way into the soil. There they live for seventeen years, sucking the sap

from the roots of plants, and doing great damage.

MILLIONS OF DOLLARS LOST THROUGH THE WORK OF A FLY

At the end of their seventeen years underground they appear as flies, and then attack the foliage of the tree, completely ruining the fruit-crop. Of course, some flies of this family appear every year, but it is only once every seventeen years that the multitudes come forth to work havoc. In 1874 the attack of these flies caused damage in four States amounting to \$100,000,000, and double that sum through losses in trade dependent upon the crops which these insects had spoiled.

There is another cicada known as the thirteen-year locust, so called because it appears in swarms every thirteenth year. The cicada is a curiosity because of its loud and musical chirping. Some people, when there is not a plague of cicadas, keep the insects in cages for the sake of their chirping, which, when the air is still, can be heard for a great distance.

Whenever we think of damage done by insects, however, our thoughts always turn to the locust. That was the first destructive insect any of us read about, for its terrible ravages are described in the Bible. The locust appears in just as great swarms to-day, and is every bit as much to be feared as it used to be in the old days.

ARMIES OF LOCUSTS THAT SOUND LIKE A RUSHING RIVER

THERE are many species of locust, and its family includes grasshoppers. Some locusts are only a quarter of an inch long; others are five inches in length. The female has a strong boring weapon, and with it she drills a hole in the ground, and there lays her eggs. When the young ones are hatched and grow strong they have hearty appetites. At first they have no wings. So they march in countless armies, in search of food.

They go straight forward, nothing turning them aside. Every green blade disappears as they go. If they are not stopped, they feed and feed, and presently their wings appear, and then they rise into the air and continue their progress by flying. Then it is that travelers see them in vast hordes. The swarms blot out the light of the sun. They fill the heavens as with a black cloud, and the noise made by the wings and the movements of their hungry jaws is compared to the rushing sound of a broad river. They alight

from time to time; and suddenly, where a few minutes before appeared a field of corn or a grove of trees, nothing remains but a mass of stubble, or a forest of bare branches.

On and on they go, traveling to lands beyond the sea. They have been met in a cloud 500 feet high, 1200 miles from land. Wherever they have passed over land they have left ruin and desolation.

A BANK OF LOCUSTS FIFTY MILES LONG ON THE SEASHORE

SOMETIMES a great wind will blow the locusts into the sea. This happened toward the close of the eighteenth century, in South Africa, where 2000 square miles of land had been covered by them. A great wind blew them into the sea, and so many were drowned that when their bodies were cast up by the waves they formed a bank four feet high and fifty miles in length. Nothing can save the farmer over whose fields or orchards a swarm of locusts flies. The only hope seems to be to grapple with them before they get their wings—when they are marching on foot. Until 1881 they used to scourge the island of Cyprus. Then two clever men undertook to solve the problem, and mastered the locusts. It was a wonderful thing that they did—wonderful because, though it was successful, it was so simple. It was solely the result of watching the ways of the locusts.

MILLIONS OF LOCUSTS CAUGHT IN ONE YEAR ON ONE ISLAND

THE young locusts always march in a straight line. What the men did, therefore, was to erect great screens of canvas, and at the top they put smooth oilcloth. Now, the locusts cannot climb over anything smooth. So here were the great screens of canvas with oilcloth at the top ready for them.

When the locusts appeared, they began to climb up the canvas, but on reaching the oilcloth they fell back, and crawled along at the foot of the screen until they tumbled into deep pits, which had been dug every few yards at the side of the screens. The pits were lined with polished zinc, so that, once in, the locusts could not get out, even if the weight of thousands and thousands of others falling on top had not prevented them. The men used 500,000 yards of canvas and dug 26,000 pits, and the result was that in the first year they caught 214,000,000,000 locusts, and in the following year 56,000,000,000 locusts. It cost more than \$125,000 to do the

work, but the money was well used. Locusts have now vanished from Cyprus. But supposing that these measures had not been taken, there would soon have been enough locusts in Cyprus alone to destroy the crops of any country to which the descendants of these swarms had flown.

There is a striking difference between the grasshopper and the kind of locust we have described. The locust has its ears under its stomach, while the ears of the grasshopper are placed at the sides of its two front legs. The locust makes its loud chirp by rubbing its rough spiny wings one against another; so do the grasshoppers and crickets. Only the males do this, however, for the females have no means of making this noise. The noise that these male insects make is their way of calling their mates to them, and the females give the best replies by going themselves to answer it.

It is evident to most of us that crickets and grasshoppers and locusts belong to the same order, but who would think that cockroaches are of the same family? The cockroach is that big, fat insect which many of us call the black-beetle. It is not a beetle, but is a member of the winged order called Orthoptera. It has, like the cricket, two pairs of wings, the outer ones of a horny character, and acting rather as a shield for the others than for the purpose of flight. The under pair, however, are excellent wings, though the cockroach runs so fast with his six legs that he rarely has need to fly.

THE STRONG JAWS OF THE EARWIG THAT BITE AND SPOIL OUR FLOWERS

IN this respect it is matched by the earwig. Some naturalists say that the earwig will not readily eat the flesh of its kind, but that is not the case. If an earwig be killed at night where many earwigs assemble, in a few minutes the dead body will be surrounded by half a dozen other earwigs, all eating away as if there were nothing else in the world for them. The earwig does not come so much into our houses as the cockroach does; it is usually to be found among our flowers. Dahlias are its special favorites, though nasturtiums will always attract it. Its sharp jaws enable it to bite pieces out of our finest blooms, while the insect may generally be looked for in any pear or apple which a bird or wasp has attacked.

The mother earwig is a really affectionate parent, and "mothers" her little ones like a hen. We must all have noticed how quickly an earwig drops to the ground if it is alarmed, or if it

wishes to get quickly to the floor from the ceiling on which it is resting.

THE EARWIG'S BEAUTIFUL WINGS THAT WE RARELY SEE

THERE is no reason why it should fall, except that it knows that its horny covering makes it safe to do so. It has the most beautiful wings folded away under the wing-covers on its back. It is quite a task to get them unfolded and then folded back again in their proper position. The wings are not shaped like those of the cricket and grasshopper, but are more fan-shaped. The pincers, or forceps, which the earwig carries help it to fold up the wings again. But those forceps can nip too.

The story about earwigs getting into our ears is all nonsense; and that brings us to another absurd fable which terrifies very many people. Men and women who are otherwise well educated are so foolish as to believe if they hear a certain ticking in the woodwork of their houses, or their furniture, that it is a warning meant to tell them that a death is about to occur in their houses. An instant's serious thought should show how impossible the thing is; but as they cannot see what causes the sound they hear, and as people have for ages and ages believed the same thing, they go on believing the story to-day.

THE STRANGE TICKING SOUND OF A LITTLE BROWN BEETLE

WHAT is the fearful "death-tick" or "death-watch"? It is a sound made by a little wood-boring insect with a stupidly long name—the *Xestobium tessellatum*. It is simply a rather fat red-brown beetle which bores its way into the woodwork of our furniture, tunnels through and through it, eating the wood which it bores, and ruining the furniture just as fast as it can. It has a thick, horny head, and the so-called death-tick is the beetle calling to its mate, as the cricket calls to his.

But instead of rubbing legs or wings, the beetle bangs his silly little head on the wooden floor of his tunnel, and that is the way he signals. Generally he knocks four or five times, then is still. Men have kept these insects at various times, and tried to make them utter their signal in the open, but without success, until one man chanced to knock gently with a pencil near the box in which the beetle was kept. Instantly the beetle thumped away with his head. And if we capture one of them and gently tap four or five times so that the beetle may hear, we can have

as many "death-warnings" as we like, whenever the beetle is not asleep or too busy feeding.

The beetle that we have been discussing is one of a family of insects which make their way into woodwork. They are as great a nuisance on land as the wood-boring worms are in the water. All the holes that we see in what we call worm-eaten wood are caused by these little pests.

THE FLY THAT SPOILS THE MILK AND SPREADS DISEASE INDOORS

WE need not leave the house to discover one of the greatest of pests, the fly. The only thing that can be said in favor of flies is that they are good scavengers out of doors, eating up all sorts of horrible refuse which would otherwise make the atmosphere foul. But in civilized countries we ought not to depend upon methods such as prevail among savages. Flies carry disease to our food. When they are most abundant, in the latter part of the summer, they poison milk and other food which little children take, and cause many deaths. Indeed the wise men of one big city where there are many poor people, came to this conclusion—that it would be cheaper for the city to provide, at its own cost, pure milk which flies had not corrupted, than to bear the cost of all the funerals of little pauper children whose deaths had been caused by dirty habits of the flies.

Nothing is too bad for a fly to eat. It settles upon poisonous refuse, then flies off with parts of the poison adhering to it into a house, and there settles down on food, leaving corruption wherever it goes. The eggs of the common house-fly are laid in unhealthy refuse, where the grubs hatch and feed.

LITTLE FLIES THAT ARE OLD AND BIG FLIES THAT ARE YOUNG

THEN they pass into a chrysalis stage, and eventually issue as perfect, full-grown flies. When we see flies of different sizes, we must not imagine that one is a young fly and another an old one. They are all fully grown when they leave the chrysalis. We have two or three kinds in our houses. One of them, the one which really bites, does so to suck our blood. It is called the stomoxys, and is a small black fly that does not appear until the autumn. The flies which we see hanging swollen and dead about the house have been killed by a fungus which attaches to them. This fungus eats its way into the body of the fly and kills it, and then spores drift off to become attached to other flies.

The bluebottle, which we almost forgive for its bright coat and breezy hum, is a dreaded enemy of the larder. It deposits its eggs upon flesh, or in wounds of animals, and there the eggs hatch and the larvæ feed.

We cannot name all the flies, for they are numerous. We must, however, not overlook the dreaded tsetse fly. This, though it may bite man, does not cause him any serious harm, but its bite is certain death to horses, oxen, and dogs. It lives in certain districts in Africa, and is supposed not to stray beyond them. It is noticed, however, that if anything occurs to disturb the wild animals and to send them afield beyond the places which they ordinarily inhabit, there the tsetse fly is also discovered. It has been suggested that all wild animals near human habitations should be killed so that the dreaded fly may be destroyed.

MEN WHO DIE TO SAVE US FROM PLAGUE CARRIED BY FLIES

As might be expected, there are innumerable varieties of flies in lands where we have heat and moisture prevailing in forest and swamp. South America and many parts of Africa are rendered almost unbearable by flies that sting and bite, while large areas in Italy—to name only one part of Europe—are the seats of disease and death every summer, as the result of winged plagues in undrained lands.

There is still much to be learned about poisonous insects, and many men are bravely devoting themselves to the work. Scientists have sacrificed their lives while studying these problems. They have gone into lands infested with deadly insects, and allowed themselves to be bitten so that they might trace the manner in which the disease begins, the insects from which it comes, and the manner of dealing with it. The story of these men is very sad but very wonderful. They are as brave as the bravest soldier that ever fought on a battlefield, for they fight, not to kill men, but to save them, and they lay down their own lives to save those of millions of people who may never hear of them or of the sacrifice they make. Naturally, where there is so much to be learned, the way to knowledge is difficult.

THE DOCTOR WHO LIVED IN A SWAMP TO STUDY A FLY

ONE of the worst diseases which afflict men who go to the unhealthy parts of Africa is called sleeping-sickness. When bitten by the insect which carries the particular sort of poison caus-

ing this disease, men become overpowered with a desire to sleep; all their energy and will-power go from them, and they die. A great doctor, Professor Koch, studied the problem. For eighteen months he lived by himself in the swampy regions round Victoria Nyanza, a lake in Africa, where poisonous insects teem in countless swarms. He believed that the disease was caused by the bite of an insect named *Glossina palpalis*. This insect breeds along the banks of the lakes and streams. It can be found from the source of a stream right down its banks running through hundreds of miles of country, spreading this terrible disease wherever it goes.

His experiments led him to a curious theory. He found that wherever there were crocodiles there also was the insect which caused sleeping-sickness. The insects, he said, live upon the crocodile in the first instance. They would seem to have a poor chance of biting these horny monsters. But they suck the blood between the armor-plates of the crocodile's hide. When a man draws near they fly off to him to suck his blood, and in so doing they inject poison into his system which in the end causes his death.

A DEADLY INSECT THAT RIDES ON THE MOSQUITO

THERE were places in Africa where the death-rate from malarial fever was so terrible that these places were called "the white man's grave." All sorts of beliefs as to the cause of these plagues were entertained. Many people thought that they resulted from poisonous fumes arising from the ground. But brave men risked their lives to solve the problem, and they found out what it all means.

They knew that death resulted when a man had been bitten by mosquitos, but they could not for a long time discover which was the deadly mosquito that actually caused the tragedy.

Among the men who studied the question in India was a brave young officer, Major Ronald Ross. He studied all the different varieties of mosquitos that he could discover. He took samples of the blood of men who had been bitten, and found in them a tiny organism which evidently conveyed the poison that caused death. But how did the organism get into men's blood? What had that to do with mosquitos?

After months and months of study he found that all the while he had been on the wrong track. The mosquito that he was seeking slept while he was awake, and came out to work its mischief while he was in bed. It was a night-flying mosquito. As soon as he discovered this,

and examined the mosquito, he was rewarded for all his labors in examining other mosquitos, for here was one different from the rest. Upon its body he noticed a little parasite. A parasite is, as we know, a small animal living upon the body of a larger animal. This parasite was the origin of the poison. Like the ichneumon-fly, it lays its eggs in the body of the mosquito. These lodge in the poison-gland of the mosquito. When the mosquito bites a man, these eggs are forced into the wound caused by the bite, and there they develop and poison the man and cause his death.

It would be of little use to find the cause of death unless we were able also to find a remedy. Now, the life-history of mosquitos, gnats, and midges is very similar. The full-grown insects lay their eggs either in water, or in damp, decaying vegetation, or behind the bark of fallen trees. There they hatch and come forth as full-grown insects, ready to carry on the work of destruction.

Now, in many countries there is very little attempt at proper drainage. Stagnant pools lie about in the streets; rubbish collects in the villages; dirty old tins and cans lie about with water in them; water-butts are uncovered; there are a thousand places in which the deadly insects can be reared. Therefore, it became evident that if men, women, and children were to save their lives from the attacks of the insects, they must be clean in their habits.

DEADLY INSECTS THAT COMPEL US TO OBEY THE LAWS OF HEALTH

THEY must allow no pools of water to collect in their streets; they must allow no swamps to remain undrained near their cities; they must have no water-tanks open, or if they are open, then petroleum must be poured into the water to kill the insects there.

These horrid little insects, for whose existence it is almost impossible to find any excuse, might seem to have been sent by Nature to teach men to be clean. Towns which had been hot-beds of disease became absolutely healthy when the new rules were enforced. Death had been frightfully prevalent among the men who are building the Panama Canal, because of the bites of mosquitos. Our government sent skilful, determined men to carry out the work of making men clean and careful.

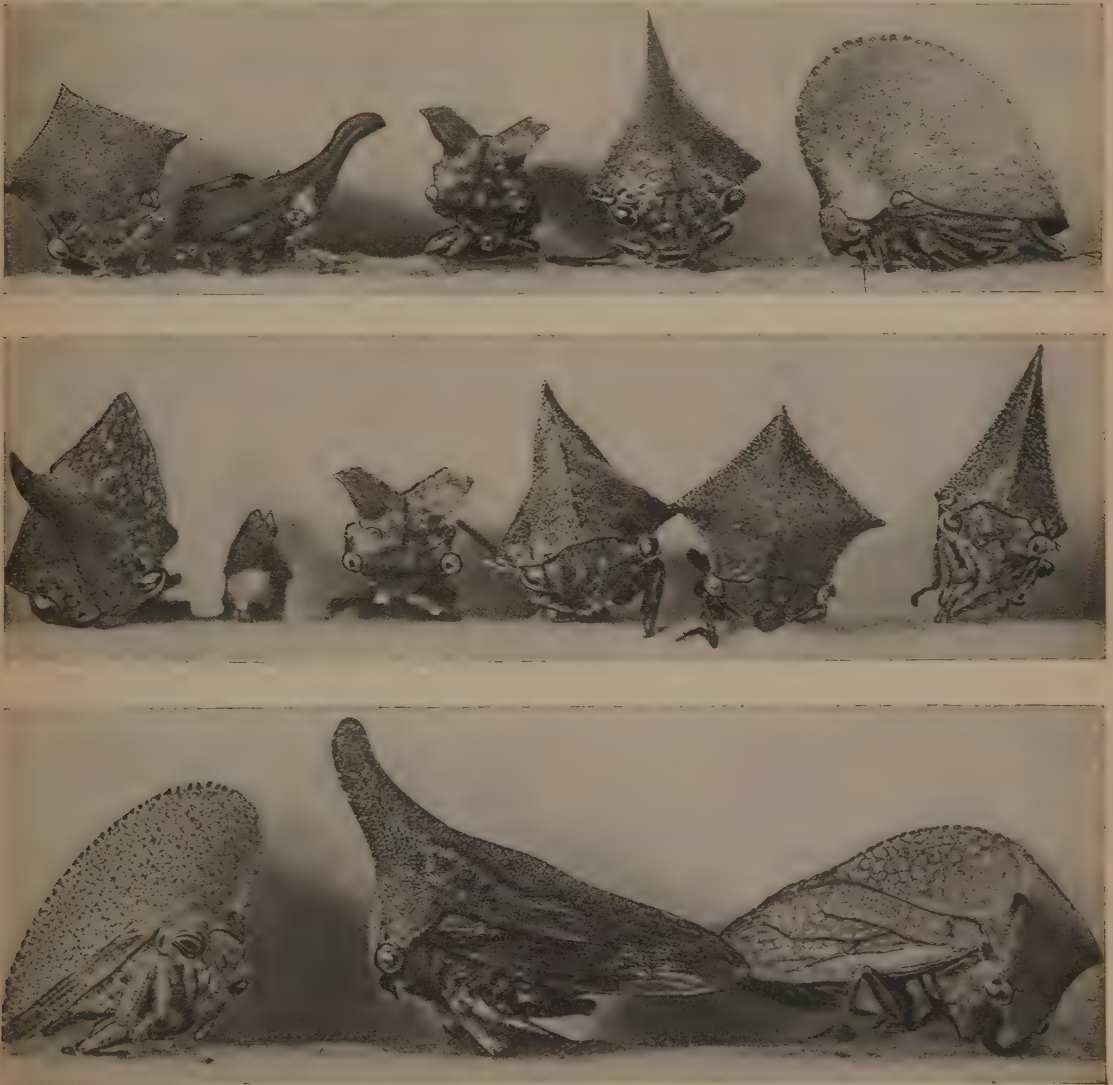
The stagnant pools were dried up; all rubbish was burned; no place was left in which the mosquitos could lay their eggs. And the result was that yellow fever and malaria, which the mosquitos had previously caused, both disappeared.

The same thing can be done for the health of people in the deadliest climates. If they will only attend to the laws of health, they need not fall victims; if they neglect them, then they fall victims to the insects which carry certain death. The same law applies to horrible parasites which afflict human beings.

LUDICROUS FORMS OF INSECTS

WHEN I first glanced at these photographs, which were sent to me by a friend, I thought that he had been carving odd-looking objects to amuse himself, and that he had concluded to

amuse me. But another look showed that they are greatly enlarged pictures of the insects known as treehoppers, because some of them can make such prodigious leaps. They are half an inch or less in length, yet some of the relatives of those shown in the pictures can jump six feet. If a man, in proportion to his size, could spring like that, he could make a standing leap of about four hundred yards. They are abundant on the trees, bushes, and grass, especially of Brazil and of other warm countries. Their relatives in our own country are peculiar in shape, but none are so strangely formed as are those of the tropics, in which the upper part of the body, the "pro-



A SELECTION FROM THE MANY LUDICROUS FORMS OF TREEHOPPER INSECTS.

thorax," is so prominently developed, and takes so many fantastic shapes, that they become the queerest-looking insects which nature has produced.

It is supposed that the enlargement of the back is intended to give them some resemblance to certain parts of plants, such as thorns and galls. Their enemies, mistaking them for growths that are not good to eat, pass them by without attacking them. The hoppers themselves live among the leaves, and drink the juices of the plants.

In the summer, in the eastern part of the country, one or more of the common forms of these misshapen little creatures may sometimes be found.

HOW NATURE USES TINY INSECTS TO PUNISH CARELESS FOLK

MANY unpleasant things, which we need not discuss, live upon the bodies of human beings if human beings are not careful. There is a parasite for everything. Animals have theirs, poultry and birds have theirs, and man has his. Man, with his superior sense, can avoid them if he will. All that he has to do is to keep himself perfectly clean and he will escape; or, if he is temporarily attacked, then he must take the proper course to rid himself at once, and all will be well. If he will but keep himself clean, he can keep himself free; if he does not, then he must pay the penalty. Nature has no mercy for the careless or the unclean.

A gnat is a mosquito and a mosquito is, of course, a gnat. Those that have feathery, plume-like antennæ are harmless. These are the males, which live upon vegetable substances. Those that have not the plume, but sit, when at rest, with the hind legs upturned, are the females, and the ones that bite.

It is the female midge, too, which bites, not the male. Midges are smaller than the gnat, and, when examined under the microscope, are really beautiful little things to look at. But they are better dead than alive, for their bite is most painful. Like the mosquito and other blood-sucking insects, they have the most wonderful tools for their work.

THE LITTLE MIDGE WITH A LANCE FOR CUTTING AND A PUMP FOR SUCKING

THEY have barbed lances for cutting and sawing, and little pumps with which to suck the blood. How it is that they cause such pain is not quite clear. Some men think that they squirt into the wound that they cause a little

drop of poison to make the blood thinner and more ready to flow. The fact is, however, that, except in a year of many midges, we think so little of them that we do not bother to examine their ways. They affect people very differently. Upon some they make merely a red spot; upon others they raise huge lumps, so big that, if the bite be upon the face, the whole eye may be closed until the effects of the bite disappear.

We ought to feel very thankful that the horse-flies do not often attack us. They are the great gray-bodied creatures which hum so loudly as they fly. They do not often bite men, but when they do they show the most alarming intelligence. They settle upon the back or shoulders, so that they may bite and not be immediately perceived; and so powerful are their tools that they can pierce thick clothing, and so reach the flesh beneath. Horses they attack by settling where the animals will be least likely to reach them with their tails.

The list of insect enemies is far from exhausted. There is a terrible array of them in the garden. Those that we have been writing of now, however, suffice to show how very careful men have to be to guard their health and property from the lesser animals of the world.

THE BEETLE WITH A FUR COLLAR AND A STRANGE "FACE"

A BEAUTIFUL brown-and-gray beetle on a branch of an evergreen tree had attracted the attention of an observing man, who brought it to my desk



THE BEAUTIFUL BROWN-AND-GRAY BEETLE.

to learn, "What is its name and how does it live?" The name, *Monohammus confusor*, I explained, is a little longer than the beetle itself,

which is only an inch and a quarter in length. The larva bores in the wood of pine and fir.



A FACE SUGGESTING THAT OF A COW.

To show to the best advantage the beautiful brown-and-gray furry covering, I placed the beetle under a small pocket-lens, that brought



"THE FUR COLLAR."

forth the astonishing exclamation, "Why, he has a fur collar, and his face looks like a cow."

I did not dispute, but merely wondered whether

B.W.&C.T. 9

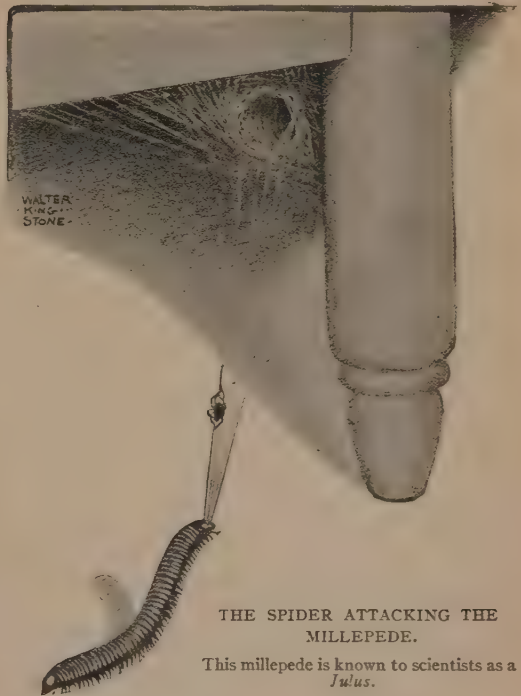
our boys and girls would agree with him. Of course I cannot pass the beetle to all of you, so I do the next best thing, and photograph it a little enlarged, with a separate picture still more enlarged of the face and the collar.

Was the visitor's jocose exclamation properly descriptive of what he saw?

A LILIPUTIAN ENGINEER

As I sat in my log cabin, awaiting the long-anticipated dinner-horn, I noticed a commotion, at the foot of my washstand, in the strong sunlight that streamed across the floor.

A house-millepede, or "thousand-legger," crawling over the lighted space, had been seen by a tiny spider, whose lair was attached to the leg of the stand, a foot above the floor.



THE SPIDER ATTACKING THE MILLEPEDE.

This millepede is known to scientists as a *Julus*.

The spider was so small that her body was not much larger than the head of a common pin, while her legs were too short to be seen from where I sat.

Like an arrow the little creature darted down an invisible thread, and, quickly touching the crawling millepede, returned like a flash to her silken home above, only to repeat the operation again and again, each time spinning a thread finer than the finest silk, and fixing it to the body of the intruder.

The millepede stopped crawling, and by thrashing its body to the right and the left did its utmost to break the silken lines. Regardless of these struggles, the spider advanced again and again, each time adding a freshly spun thread to the victim's body.

Then the millepede changed its methods, and, instead of throwing the body first to one side and then to the other, began to crawl backward, using its entire strength in attempts to break the cords that held it. The spider, like an animated speck, wove the web and strengthened the lines unceasingly. By looking closely I could see that in some mysterious way the gossamer threads were actually drawing the captive off the floor.

The millepede was now desperate, and, clinging with its hindmost feet, it swung the front part of the body free from the ground, and made frantic efforts to break the threads.

A bee never worked more industriously than that little spider. She, like myself, was expecting her dinner, and, unlike me, was working for it industriously.

The millepede was now relaxing its efforts. The many feet were gradually leaving the floor; only two or three seemed to be holding fast, when suddenly, and strange to relate, the "thousand-legger" swung clear, and, through some unseen agency, was lifted inch by inch until it reached the very web itself. The spider then swiftly wrapped it in a sheet of silk, and the captive struggled no more. The spider, although only perhaps a thousandth part of the weight and size of the house-millepede had succeeded in capturing it and in actually lifting it bodily to her lair!

For a child to throw a lasso around an elephant's neck, and then, climbing a tree, to pull the elephant after him, would not be more wonderful than was the work of this little spider that captured the comparatively gigantic "thousand-legs," and lifted it up to her den.*

CHARLES CRISTADORO.

SOME INSECT FRIENDS

THERE was once a stupid fellow who saw a toad, one of the best friends of the gardener.

"Toad, are ye? I'll learn ye to be a toad," he said, and brought down his spade, whack! on the poor toad's head. That is just the sort of thing that ignorant people would do, not only with toads and reptiles of every kind, but with all sorts of insects as well. We know that cer-

tain insects are harmful to man; but let us be fair and look at the case of those which are our friends.

We will take in more than insects, too, for we will say a word for the humble worm, which is not an insect, as, of course, we know. Most people hate worms, and kill them when they can. Yet worms are industrious helpers of the farmer and gardener. Darwin studied their habits closely, and found that they help greatly in making our soil good and fertile. They eat the earth in which they live, just as the wood-borers eat the substance in which they make their homes.

The worms bring to the surface the earth which they have eaten. They make channels in the soil by which the air can enter and give the soil the nitrogen it needs for making it fruitful. They carry down pieces of grass and straw, and these help the process. But most important is their work in bringing to the surface soil which has been lying below. Darwin found by calculation that the worms on a single acre of land bring up ten tons of dry earth to the surface every year.

Some savage peoples are really far wiser observers of Nature than we are. They realize the value of earthworms. When a native of the Yoruba country, in Africa, decides to cultivate new soil for a farm, for what sign does he look? He looks for the evidences of earthworms. Probably he has never taken the trouble to reckon up how much work the earthworm actually does. He cannot go into figures as Darwin did. But he does know that the earthworm makes the soil good for crops. So if he sees that worms are at work upon a tract of land, it is there that he sets to work to farm. If the land lacks worms, he knows that there is no use in his attempting to farm, and he goes farther afield until he does find them. Probably few people who are interested in evidences of past civilizations think that they owe anything to worms. But they owe a very great deal. Those beautiful tessellated pavements which the Romans made in Britain have been preserved for us almost entirely by worms. They covered them with soil, in which they have been secure for a thousand years. But for the worms these precious relics of the past must long ago have been destroyed.

The most charming of all the things which bear the name of worm is a creature which is not a worm at all—the glowworm. The glowworms, as we call them, are really beetles, and do us good service by entering the shells of snails

* The so-called millepede (thousand feet) has only about one hundred feet or legs. Our common centipede (hundred feet) has about fifteen pairs. So you see that the people who first named these interesting little animals greatly exaggerated or else did not make careful count.—Ed.

and devouring the occupants. Naturally, they move about at night, or they would not need the wonderful light which they are able to produce.

THE MARVEL OF THE GLOWWORM AND ITS WONDERFUL LAMP

THE light is phosphorescent, and is produced from fatty cells, to which run many tubes carrying the oxygen necessary for the light. The operation of this light is as wonderful as the operation of the batteries of the electric fishes. The rays of light which the glowworm gives off are said to possess the same properties as the famous X-rays—they will pass through solid substances through which the eye cannot see. Men can produce light by gas and electricity, of course; but they cannot do as the glowworm does—produce light without heat. This humble beetle has a power which man cannot imitate.

All the energy that it uses goes to making light; none is wasted in heat. The male glowworm has wings, and flies about on summer nights, showing his light frequently, but for short intervals. The female has no wings, but shows her light to attract her lover. He is delighted when he finds her; but she is very heartless, and when he arrives she continues to flash forth her light to attract other males, so that she may have a number of them buzzing about her to sadden the heart of the first arrival, her real sweetheart.

The powers of the light given forth by the glowworm are very great considering how small the beetle is. Placed in the dark, the glowworm yields a light strong enough to enable us to read print by it, or to tell the time by a watch. There are hundreds of species of this beetle and other light-giving beetles.

THE FIREFLY THAT IS REALLY A BEETLE AND LIGHTS UP THE FOREST

THE fireflies, like the glowworms, are really beetles. In many parts of our own country, in the West Indies, in South America, in some parts of Canada and of the Orient, the forests at night are like dreamlands or fairy worlds. The fireflies wing their way in countless swarms around the trees, lighting up the foliage as with gleaming diamonds. After rain the air seems filled with trains of flashing stars, waving about the tree-tops in glowing circles, making the scene such as might inspire the mind of poet or painter.

These wonderful creatures have their real use, as well as beauty, for the traveler. Men who

would not dare to pass, unlighted, through the forests at night attach fireflies to their boots to light the path they tread. Thus lighted, a man goes on his way as in daylight, and when the sun gets up, he gratefully replaces his living lanterns on a shrub so that they may live to serve others in the same way.

Certain birds use the fireflies to light their nests. Natives of some lands make lanterns of them. Spanish ladies wrap them in gauze, and use them as ornaments for their hair; and young people sometimes decorate their dresses and the harness of their horses with them.

A LITTLE FLY THAT FIGHTS FOR MAN AND SAVES OUR GARDENS

WE must leave these beauties, however, and pass to another noted family which is famous, not for its beauty, but for its service to man. This is the family of ichneumon-flies. There are thousands of species, and it is safe to say that men engaged in agriculture would be helpless without them. They lay their eggs in the bodies, or even in the eggs, of harmful insects, and so destroy these while multiplying themselves. The female has what is called an ovipositor. This is a sort of combined spear and tube. With the spear she makes an opening in the body of the insect in which she is going to deposit her egg; then, having made it, she produces an egg from the tube, and leaves it in the victim's body. Sometimes an ichneumon will lay its eggs in the body of another ichneumon, but generally they choose other insects, and keep each to its own class of victims. Let us watch one at work on a rose-leaf.

BATTLE FOR LIFE BETWEEN INSECT PESTS AND FRIENDS

ALTHOUGH the aphides make very good cows for the ants, they are terrible enemies of our rose-trees, whose leaves they spoil by robbing them of their life-juice. Down comes an ichneumon-fly. She walks on her high, stilt-like legs, over the leaf until she sees a plump aphid. She touches it with her antennæ.

If the aphid were thus touched by an ant it would quickly produce some honey, but now it knows that a deadly enemy is at hand. It begins to wriggle violently to escape the doom which instinct tells it is near. The fly may wait until the aphid has finished wriggling, or may even give up and go to another victim. But in the end she is successful. One thrust of her lance in the back of the greenfly's neck makes the

nest of the egg. In that wound the egg is placed, and the ichneumon, having fifty or sixty such eggs to place, hurries on elsewhere to continue her task.

The aphid does not die. It knows what has happened, and, leaving its companions, crawls away to a leaf to be all by itself. Presently the egg hatches, and the grub which leaves the cell lives upon the flesh of the aphid. We can only hope that the latter feels no pain. It seems a dreadful story, but naturalists suppose that the aphid suffers a sort of paralysis, which mercifully prevents it from feeling discomfort.

THE TINY FLY THAT KILLS THE FOES OF THE COTTON-PLANT

WHEN the grub has reached a certain size, the aphid dies. Then the grub makes its way out of the dead body and spins a silken cocoon in which it undergoes changes, and finally comes forth as a winged ichneumon-fly. In that stage it lives upon the juices of certain flowers, and in its turn goes out to find aphides in which to deposit its own eggs. But for the ichneumons, men would be helpless against the attacks of caterpillars, greenfly, and other things of the same sort. The blessing is that they make their attacks upon insects which are among the most numerous in the world, and from which we suffer most injury.

There is a very important ally of the ichneumon-fly of our gardens called the chalcid-fly, a fly of many species. The cotton-plant has terrible insect enemies, and the chalcid-flies are the only things to keep them down. The chalcid is no match for the fully developed insect, but scientists have found that it destroys millions of the eggs of these larger insects, and so saves the cotton-plant from being ruined by the grubs which would issue from the eggs if the latter were left undisturbed.

A FLY THAT HAS CROSSED THE OCEAN TO MAKE POOR FRUIT RICH

ANOTHER thing that one of the chalcid-flies does is to give to California figs which now rival those of Smyrna. Smyrna figs have been from early times the best figs in the world. Farmers in California bought trees from Smyrna, and made them grow in California, but the fruit was not the same. Clever men of science studied the problem and solved the mystery. They found that the Smyrna fig-tree is the home of a chalcid-fly which, with its saw-like weapons, cuts into the fig-bud, and so introduces pollen which makes

it big and sweet and rich. Chalcid-flies were therefore placed upon the trees in California, and the figs grown there under these conditions are as good as those of Smyrna. Here, then, are two examples of the great value to men of some of the smallest of Nature's offspring.

The ladybird is another of our friends in this country. People have such a horror of anything called a beetle that it is just as well that the ignorant do not know that the ladybird is a beetle, or, in spite of its great work for us, it would be killed by the stupid. We like to pet the ladybird because it is so pretty and so fearless. But its real value to us lies in the fact that it eats the insects which destroy our plants. One species lives entirely on the aphid, the rose-pest; other species lives on those tiny animals which we call scale-insects—the insects that ruin hops and fruit-trees. The young ladybirds might be in danger of being killed if people did not see them devouring the plant-lice—they are so unlike their parents. They look like tiny crocodiles when they first begin to run about the leaves on which they have come from the egg. Soon, however, it is seen that they are hunting aphides, and then their mission is realized to be one of value. The full-grown ladybirds have to seek warm retreats in the winter, and it is then that many get into houses. They can be safely handled and examined. If they are roughly treated or alarmed they have the power to emit a yellowish fluid with an unpleasant smell.

HOW INSECTS ARE VALUED FOR SAVING CROPS

So valuable are the ladybirds that they are sent from country to country. A cargo was sent to California to destroy the scale-insects which were killing the orange-trees there. These were so successful that a cargo was sent from New Zealand to England to cope with the scale-insects which were multiplying on the hop-plants. Unfortunately this was not such a success. The climate of England did not suit the little visitors so well as that of their native land. They found the hop-plants too high for them, and refused to seek higher than three feet from the ground. Finding the work so unsuitable for them, they gradually forsook the hops and worked away at the scale-insects on the currant-bushes in nursery-gardens.

The beautiful dragon-fly is another of the creatures which are commonly misunderstood. It has a spear-like tail, and when threatened curls this up and down as if it meant to sting. This might frighten a larger enemy; it certainly

frightens ignorant human beings, who call it "horse-stinger" and kill it, when they can, in the belief that it is an enemy. They kill a very good ally by so doing. The dragon-fly, though it does not and cannot sting, is a sort of king of the insect world. It lives on other flying insects, and when we see it dashing about in the air like a flash of light, it is simply hunting prey which, if left, would injure us. Its powers of flight are marvelous, and it is impossible for a man even with a big, long-handled net to catch them when they are flying.

THE GORGEOUS DRAGON-FLIES THAT TRAVEL AS FAST AS TRAINS

THE dragon-flies seem to know exactly what a pursuer means to do, and no matter how swiftly he may move, no matter how cunning he may be, they always manage to keep just out of reach of his net. They must be caught when at rest, if at all. It is the swiftness of their darting, swallow-like flight which makes them so certain of catching mosquitos and other insects on the wing. They can catch insects when flying at the rate of forty or fifty miles an hour.

To enable them to make their rapid pounces in all directions, they need fine eyesight. And they have almost, if not quite, the finest eyes in the insect world. Their nearest rivals in this matter are the butterflies and day-moths. Not only are their eyes big; they are compound, made up of an enormous number of facets, each of which is an eye to itself. The dragon-fly has practically from 15,000 to 20,000 eyes in each of its eyes, and through each tiny angle can see as clearly as we can see with our eyes.

It must not be thought that the dragon-fly is an exception in having these marvelous compound eyes. The point is that the eyes of the dragon-flies differ in degree of strength, not in kind, from the eyes of other insects. Nearly all insects have these compound eyes. Our common house-fly, for example, has thousands of cone-shaped eyes bound into one big cone-shaped eye, and each facet is a separate self-working eye, though part of the greater eye.

AN INSECT WITH 25,000 WINDOWS TO ITS BRAIN

THE house-fly, as he darts across the kitchen or into the larder, has 8000 chances of seeing food or the cream-jug. The common beetle has 6000 chances of seeing something worth looking at, while the mordella-beetle has over 25,000 windows to its brain.

We must not leave the dragon-fly without a word as to the manner in which he came into the world. His life-story is similar to that of the mosquito. The eggs are laid in fresh water, and hatch there. The larvæ eat very hungrily, strong nippers in front enabling them to grasp and eat quite big insects and other forms of food. Their breathing is very curious. In a way it is like that of a fish. They have no windpipe or lungs, of course. The water enters the lower part of the body, where many little tubes extract from it the oxygen necessary to the insect's life. Then the water is forced out again, and the pressure of the water going forth is sufficient to drive the larva on its way without its troubling to swim by other means. When the time for a change comes, the larva crawls wearily up the stalk of a plant. He is feeling far from well. There he rests for a while. Suddenly the dull old coat in which he has been floating about splits down the back, and lo! a gorgeous dragon-fly creeps forth. He has wings now, small and damp and crumpled; he would be helpless if an enemy sought him. But he waits, and the sun dries him, his wings harden and expand, and very soon he rises into the air in all the majesty of four splendid wings, and with a coat of mail bright and shining as the mail that the knights wore in days of old.

THE BEAUTIFUL DRAGON-FLY AND THE HARMFUL GADFLY

SOMETIMES we hear the dragon-fly called the gadfly. There could not be a greater mistake. The gadfly is another name for the bot-fly, one of the greatest enemies we have. The horse-bot lays her eggs on the hair of the horse, in some place where the horse will be sure to lick itself. The eggs cling to the tongue of the animal and are swallowed. They remain in the stomach of the horse all the winter, and, leaving the body of the horse in the spring, burrow into the ground, and there become flies.

The ox-bot is more generally known as the warble-fly. This horrible creature serves the cattle as the ichneumon-fly serves the aphid and caterpillar, boring a hole in the hide and laying its egg there. Cattle are terribly afraid of the warble-fly, and will sometimes gallop themselves to death to escape it.

The sheep-bot is the worst of all, for this crawls into the nostrils of the sheep and lays its eggs there, where the grubs, on hatching, sometimes crawl into the brain of the poor sheep and kill it. These are the gadflies, so we must never

again confuse our gay friend, the dragon-fly, with them.

The dragon-fly and the mosquitos are by no means the only insects which undergo such surprising changes, being born in water, to fly in the air. The same course of life is followed by very many others with which we can afford to be on the very best of terms.

THE SNUG LITTLE HOUSE THAT THE CADDIS-WORM BUILDS

THE caddis-fly, for example, deserves a chapter to itself, could we spare the space. The eggs hatch in the water in which they are laid, and the grubs are called caddis-worms, which fishermen are only too glad to secure for bait. They make the most wonderful nests for themselves in which to pass their days under water.

They gather bits of sticks and leaves, grains of sand, and tiny fragments of shell, and cement them all together to make the snugget of houses. Some cut leaves and twigs into short lengths, and cement them together to form a tube. Others build up a home made of shells, in which the little animals to which they belong are already living, and the living molluscs are fastened round to make a live belt or shield for the caddis-worm.

Inside these tubes the caddis-worm spins a robe of silk which leaves its tail covered, but permits its head and legs to come out, so that the larva may collect its food of vegetable or animal substance. When they are to undergo their change, they close up this front door, either with plates of silk or with stones, so that the water may come through, but not animal enemies. Before the great change quite arrives, the larva must come out again, quit its cell for ever, and climb up on to a plant, where its shell will split open and it will appear as a pretty winged insect, the caddis-fly proper.

MAY-FLIES THAT LIVE LONG IN WATER AND ONE DAY IN AIR

ALL this discussion of insect changes must have made us think of the life of the May-fly, or day-fly, as it is also called. The story of its life in the water is similar to that of the other insects of which we have been reading. But here the life in the water may last for two or three years. In that time the larva lives a busy life, hunting and feeding on other insects, making itself dwellings in the sand or mud, and slowly, very slowly, preparing for the time to come. Finally, the great day arrives; the pupa stage has been

passed, and the insect climbs out of the water all ready for flight, except that it is still wrapped in its pupal robe. This has to be worked off, and then the May-fly mounts into the air. The flies may be seen in millions and millions on a summer evening, dancing and eddying in the warm air over canal or pond or stream. Their lives in the air never last more than a day. Often only an hour passes between the time of their leaving the water and their death. In that short time the females lay hundreds of eggs on the leaf of some water plant. Then they die. Their life in the air has begun and ended in, perhaps, an hour, after they have spent years in the water preparing for it; and at the end of that hour their dead bodies lie in such multitudes that they may be swept up and strewn on the fields for manure.

THE CUNNING ANT-LION THAT DIGS A PIT FOR ITS PREY

It is to this order of insects that one of the most extraordinary, the ant-lion, belongs. After it has undergone its change, the ant-lion becomes a pretty fly, but it is while in the larva stage that it most interests us. It makes a pitfall in which to catch its prey, and this is the way in which it does it: selecting a dry, sandy spot, it first marks out a circular furrow; then it places itself in the center, and, half burying itself in the sand, it begins to dig. It uses one of its legs as a shovel; with this it throws up the sand on to its head, with which it jerks the material out of the circle and beyond the furrow. In the cleverest way it thus makes a tunnel down into the ground, funnel-shaped, two or three inches wide at the top, and narrowing down to the bottom.

When the work is finished, the ant-lion practically buries itself in the sand at the bottom of the pit, and waits, listening, for an insect to come along. Presently, down topples an ant or something else; the ant-lion springs from its hiding-place, and, seizing the victim with its strong jaws, holds it until it has sucked all the juices from its body; then it throws the body out of the pit and waits for more. Should the prisoner be skilful enough to escape from the ant-lion and start to crawl up the side of the pit, the ant-lion at once flings up sand or earth with its head, and so causes the runaway to fall down again.

THE PRAYING-INSECT THAT HELPS MAN BY KILLING INSECT PESTS

WE turn now to another famous insect, the praying-insect, or praying-mantis, as it is called.

Though they can fly, insects of this kind do not pursue their food on the wing. They wait on trees or shrubs till a victim draws near. The head is bent down and inward, the long, powerful front legs are folded and held up as if the creature were praying. But the instant a fly or other insect draws near, the big front legs shoot out and seize it, and down the throat of the mantis it goes. We must regard it as a friend of man, for it kills and eats a great number of injurious insects. There is one species of mantis in India which is most wonderfully colored, so that when it rests it looks like some gay orchid. Insects approach it believing it to be a pretty flower, and are at once seized and gobbled up.

HOW THE DEVIL'S COACH-HORSE SLAYS A CATERPILLAR

GOING to the opposite extreme we come upon the up-curving body of a very fierce-looking beetle. We point a stick or a finger at him, and he opens his strong jaws and curls up the back part of his body, and looks ready to fight. And so he is. He is the big rove-beetle, which we call the devil's coach-horse. For all his black, ugly body and threatening looks, he is a prime favorite with all gardeners who study natural history.

His appetite is as big as his courage. The devil's coach-horse will attack any insect, no matter how big. With a snap of its great jaws it will cut caterpillars or earwigs in half, and make a meal of them. Snails and slugs are among its dainties, and it will eat any carrion which it may find. The devil's coach-horse belongs to a big family of rove-beetles.

We have read so much about eggs deposited in the bodies of live creatures that we may turn now to beetles which choose dead bodies for the purpose. These are the famous burying-beetles. We never see them unless there happens to be a mole or mouse or some other small animal lying dead in the garden. Then they come up as if from nowhere, husband and wife, busy as can be, and claim the body as if they had bought and paid for it. Folding their wings, they at once begin to dig.

If the soil on the spot is not of the right sort

for their work, they drag the dead animal to some place more suitable. To do this requires extraordinary strength in beetles, but they have very powerful jaws. The digging begins with a circular furrow like that made by the ant-lion, and then another is made within that. They keep digging away until the body begins to sink. When it has sunk far enough they throw over it the earth which they have excavated. Then they feast upon the body, and the female lays her eggs in it, so that when the larvæ hatch they shall find food ready at hand. Then off they go again.

Of course, these are not the only beetles to bury things. The sacred beetle of Egypt does it, too. This beetle, whose proper name is the scarabæus, belongs to a numerous family. It collects refuse, makes it into a ball, and rolls it into its hole in the ground. There it feeds untiringly, for a fortnight at a time, without resting, until the mass is gone. In other balls of refuse it deposits its egg, and from this, in due course, the young scarab issues. The Egyptians used to think that the old scarab died on entering the ground, and that the young scarab was the same beetle resurrected. Many other silly traditions of this sort came to be associated with this beetle, and it was as sacred to the Egyptians as the ibis. They worshiped it while it was alive, and after its death embalmed it, just as they embalmed their own monarchs. And yet it is only a scavenging beetle of very unpleasant tastes.

Returning to our garden again we must say a word for another beetle or two. Nearly every one that we find there is a friend, living upon injurious grubs and insects. The tiger-beetle and the violet ground-beetle deserve special mention as among helps of the gardener. The tiger-beetle has about a thousand species, but the majority of them are in hot lands. Many are pretty and active, and possess great jaws and powerful wings. They live entirely on insects. The list of friendly insects is far from complete. There are, indeed, thousands and thousands of different sorts of insects that are harmful to us, and there are probably just as many that help us. We can all extend our knowledge by watching the daily lives of the insects around us in our gardens and elsewhere.





THE BUMBLEBEE

BY BARNEY HOSKIN STANDISH

the ground. If
fers the thistle,
aware that these
snake while his own

There are three
workers. The queens
first few weeks of spring
is the signal for nest build-
about the lilacs, thrust their
haustless honey-jars of the

Nest-building with them
well do that; besides she is in a big, bustling hurry now; she has actually seen a clover-blos-
som. Out and in among the dead, matted grasses of last year's growth she goes, hunting perhaps
for the abandoned nest of a field-mouse. It will be remembered that these little animals build
upon the surface of the ground soft nests of grasses, in which they winter. From these they
have runways leading in different directions. The bee goes down into the dead grass, scram-
bling on as best she may, until she finds one of these runways, following it up to the nest. If
it is occupied, she goes elsewhere; if not, the mouse-nest straightway becomes a bee's nest and
the little creature begins her preparations for housekeeping.

She now collects a mass of pollen in which to deposit an egg. As the egg hatches and the
baby bee grows she keeps this mass moistened with honey, and he helps himself, eating out a
cavity larger than a white bean. In this he spins a complete cocoon. When this is done

THIS chunky, hairy, noisy fellow is king of
the cold. He stays with us summer and winter,
and is said to prefer the Arctic
region to the tropics. I do not
doubt this, for he will sleep out of
doors any cool night of spring or
fall without asking for an extra blan-
ket. Indeed, he is homeless for nine or ten

months of the year, lodging wherever night over-
takes him, on a blossom, a leaf, and even upon
he has any choice in the matter I think he pre-
where the spines are thickest. Perhaps he is
stingers will guard him from the skunk and the

are in a body stiffened by cold and drowsy with sleep.
kinds of bumblebees reared in a nest: queens, drones, and
alone survive the winter. They apparently spend the
waiting for red clover to bloom, the first blossom of which
ing. Before this they visit the willows, hum a soft bass
long tongues into the honeysuckles and grow fat at the ex-
waterleaf, and then the play-day ends and labor begins.
does not mean nest-construction. One bee alone could not

he takes a long nap, in which he changes from a grub into a bumblebee, with wings and legs. Meantime the parent removes the thin coating of pollen from the upper half of the cocoon and apparently spreads a yellow secretion, or varnish, up-
 She is also collecting pollen and laying it and constructing a rude cell which to
 on it, as if moisture.
 now busy more pollinating eggs in constructing a or two in place honey-
 ey, as if for a rainy day. The first bees that hatch are worker-bees, and at this time are downy, pale, and baby-like in appearance, and behavior. In later summer, queens and drones are raised.



Recently, I watched a nest carefully, from June first, the day of its foundation, to its abandonment in mid-August. In it five broods were reared, each one like its predecessor, only more numerous. No eggs were laid in cells, as is the case with the honey-bee, and no cells from which bees had hatched were used again for brood. A few of them were used for honey, and a few for pollen; but they were usually cut down and removed to make room for the new brood, which was each time started in a pollen-mass, making cocoons side by side.

It has often been said that these cells are made of wax. Careful experiments tend to prove that there is no wax either in the honey-cells made by the bees, or in the cocoon-cells made by the larvæ. In other words, the bumblebee does not secrete wax. If we compare its conditions and surroundings with those of the great wax-producer, the honey-bee, we shall see how unlike they are. The latter, while secreting wax, hang in masses, often of many thousand, as if to generate heat; cold effectually checks secretion. Now, the queen bumblebee starts her cells single-handed and alone, in an open house where the temperature may not be high enough during a single hour of the day for the secretion of wax. During the whole season she may not have a dozen assistants at one time. Her dark-colored honey-cells, therefore, are made of pollen grains dirt specks, and honey, apparently varnished within. The yellow oval cells are the cocoons made by the

young bee, and apparently smeared with a yellowish secretion or varnish, in which there is no wax. Whether this secretion is produced by the larva for the fastening of its threads to the walls, or whether by the bees without, I have not determined.

The length of life of a queen bumblebee is probably little more than a year at most. Here is one reason for this belief. She hatches among the late broods of summer, and soon after leaves the nest, leading a vagabond existence, night and day, among the autumn flowers. The winter she passes in an earth-burrow dug by herself, and unaided establishes a colony in the spring. These combined periods of fall and spring require the daily use of her frail wings in the field at least four months. Now, we know that the wings of the worker honey-bee wear out in less than half that time; also that the old queens who take to the field after the nest breaks up in August frequently have tattered wings and soon disappear. Nature does not supply insects with new wing cells, as it supplies birds with new wing feathers. So the loss of the power of flight at this season of the year to the queen bumblebee means the loss of life.

The queen bumblebee has pollen-baskets and a sting, and if held in the hand will use the latter if possible; but she will desert both nest and brood before she will attack man in their defense.

Workers are the smallest bees of the nest, and they have both stings and pollen-baskets. When they begin to appear in the field in July the queens disappear from it until the young queens make their appearance. The life of a worker-bee doubtless is less than two months long, and its wings are subject to wear, like those of the honey-bee.

Drones are without pollen-baskets and are stingless; but they work on flowers and have capacious honey-sacks, which they freely empty as tribute when caught. On the thistles of autumn they are as abundant as young queens, but, as they do not survive the winter, their lives are, doubtless, as short as those of the workers.

The work of the bumblebee in bringing about the cross-fertilization of flowers is as important as that of the honey-bee, and these

two stand at the head of the list of insects useful in this respect. Each has its flowers which it alone visits, but there are many flowers on neutral ground, visited by both. So we may say of the bumblebee, as of the honey-bee, the more bumblebees the more seeds; the more seeds the more flowers—especially wild flowers, as the tall bellflower, touch-me-not, Solomon's-seal, gentian, Dutchman's-breeches, and turtle-head. But probably the most important work this insect does for agriculture is upon the fields of red clover. There is abundant proof that this plant will not produce seed without the coöperation of the bumblebee. It is impossible for the wind to bring about the fertilization of the seed, as it may do in the case of Indian corn, grain, and some forest trees. The tube of red-clover blossoms, too, is so long that other insects (including the honey-bee) are not regular visitants.

Here is proof that this plant must have visits from the bumblebee. This insect is not a native of Australia, and red clover failed to produce seed there until bumblebees were im-

ported. As soon as they became numerous the plant could be depended upon for seed. Again, the blossoms of the first crop of the "medium red clover" of our own country are just as perfect as those of the second crop, but there are too few bumblebees in the field, so early in the season, to produce fertilization; hence little or no seed in this crop. If bumblebees were sufficiently numerous there is no reason why much larger yields of clover-seed might not be expected than at present.

Here is what a well-informed farmer says about it:

"It was formerly thought that the world rested on the shoulders of Atlas. I can prove that its prosperity rests on the bumblebee. The world cannot prosper without the farmers' product. The farm will not be productive without clover. We cannot raise clover without seed; and we cannot have clover-seed without the bumblebee, because it is this insect that carries the pollen from flower to flower, securing its development and continuance. Let us learn to know and to protect our friends."

THE BUMBLEBEE'S SONG

BY ANNIE WILLIS McCULLOUGH



THIS song of the bumblebee
He sings for you and me,
As he buzzes about the vine
Where the morning-glories shine:

"O good my little gentlemen, the world is all a-jumble
With pretty maids, and pleasant glades, and blossoms in the sun!
O good my little ladies, there is no cause to grumble,
The weather 's fine, the hour 's mine, the morning 's well begun!"

Thus singeth Sir Bumble,
With many a stumble,
As he buzzes about the vine;
But he blunders along
And sings his low song,
As he sips the nectar fine.

FLYING-MACHINES AND AIR-SHIPS

AIR-SHIPS

BY DAY ALLEN WILLEY

WE use the word "air-ship" for the various designs of mechanism by which a man can move through the air; but strange as it may seem, the term cannot be found in all the dictionaries, so recently has it been coined. And in any case it is a word that seems misleading; for the name "ship" is associated with something that has sails. The air-ship, as we know it, is usually a bag containing gas or hot air, which is driven in various directions by an engine and steered like a boat, with a rudder. It is useless without its gas-bag, and cannot be kept in the air merely by its machinery. Really the aeroplane can more correctly be called an air-ship, because it has wings or sails against which the air-currents press and thus aid, not only in holding it above the ground, but in giving it motion.

If we call the aeroplane an air-ship, it is not a new idea by any means; for as far back as the year 1879 an ingenious man, Victor Tatin, a French scientist, made one which went through the air at the speed of twenty-five feet a second, or over a quarter of a mile a minute. As those were the times when the modern gas-engine, such as we use in the automobile and "power-boat," was unknown, compressed air was the motive force. It passed from an air-chamber into two propellers which forced the aeroplane through the atmosphere as a boat goes through the water. This air-ship, which made its successful flight at Meudon, near Paris, had two "wings" of light silk stretched on wooden frames which kept them distended. These wings or sails could be turned in different directions like the sails of a yacht, only, instead of being arranged up and down or in a vertical direction, they were nearly horizontal.

It is worth while to describe Tatin's air-ship because nearly all which have since been tried

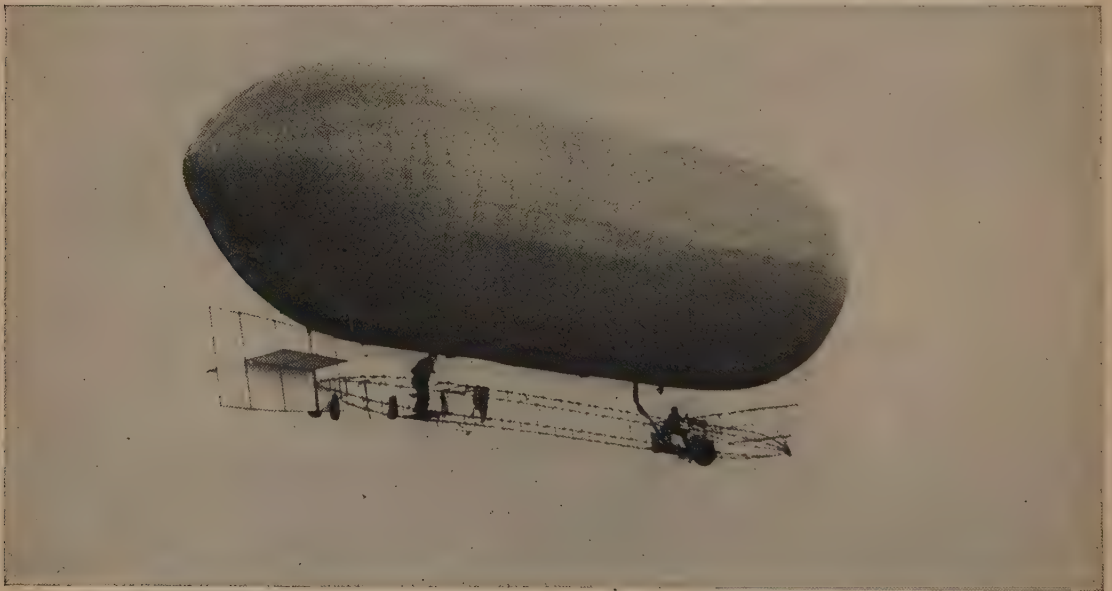
have been modeled with sails or wings. Of course, each type is different from its fellows, but usually in the number and shape of the sails. No man has invented a type which is without them, but the inventor has wrought such wonders with the engine that a motor has recently been built in Europe which actually has a power equal to the strength of a hundred horses. The ordinary steam-engine of this force would weigh so much that it could not be used for even the automobile, saying nothing of air navigation; but this European model is so very compact and light that two men can easily carry it on their shoulders. This is because it requires no heavy cylinders or boiler, which would be needed if it was operated by steam. No, its energy all comes from the explosion of gas. It has little tanks or cylinders into each of which a tiny spray of gasolene or some other inflammable oil is thrown, mixed with air. This vapor is fired by sparks from an electric battery. As it explodes it generates a gas so powerful that a little of it has as much strength as a much larger volume of steam—a strength that sends the motor-car whizzing along the highway at the speed of an express-train, and the power-boat rushing through the water at the rate of twenty to thirty miles an hour.

Yes, the vapor-engine, or whatever you choose to call it, has done more to make the real air-ship a practical device than anything else; but until recently, only the craft which had the gas-bag was capable of going into the air and making a journey of more than a few miles, in spite of the hundreds of kinds of wings and engines that have been fashioned. A few of those who would navigate the air as the sailor navigates the sea, have tried both the wings and the gas-bag. Santos-Dumont, the young Brazilian who made himself famous by what is termed the "dirigible

balloon," has experimented with the "flying-machine" or aeroplane as well, but the greatest distance he has ever gone is only a few feet compared with his balloon flights. One of the first, if not the first, successful aeroplane to be built in the United States was that with which the Wrights "flew" about a mile above the bleak sand beach of Cape Hatteras, North Carolina. The two brothers, who lived in the city of Dayton, Ohio, became convinced that they could construct wings so that they could fly like a bird. Going to this out-of-the-way corner of North Carolina to keep the rest of the world from knowing of their experiments, they made several gliding-machines, as they called them—boxes of light canvas held in shape by wooden sticks. These were open at the sides and not unlike the box-kites which are so much in use nowadays. Fastening a box upon his shoulders, one of the brothers would make a running start on the crest of a sand-hill and leap from the top with the wind facing him. This plan was so successful that one of the Wrights made a flight of 300 feet before he again touched the ground. The

The Wrights have designed types of aeroplanes for use in France as well as the United States. The American design was accepted by the United States government for military purposes after it had made an aerial voyage lasting over an hour, and at an elevation at times of 250 feet above the earth. In September, 1908, Orville Wright performed this successful feat with Lieutenant Frank P. Lahm, the aerial expert, as a passenger. This aeroplane, which was the most practical design which had yet been built in America, was forty feet in length. Its weight without passengers was 850 pounds, including a gasoline motor having the power of forty horses, which drove it through the air at the rate of thirty-nine miles an hour—the speed of a fast railway train.

Besides the box-kite there is the old-fashioned design still used by the boys fond of kite-flying. This is the kind where two sticks are fastened in the form of a letter X and a crosspiece attached, the upper opening of the X being smaller than the lower. That great scientific kite-maker, Alexander Bell, has changed this form into what he calls the tetrahedral kite, which will easily



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BALDWIN'S DIRIGIBLE (OR "STEERABLE") AIR-SHIP.

trials, however, led them to give up the idea of flying like a bird without some other force than air-pressure, so they designed several little engines for their aeroplanes, and with the aid of one of these they traveled a distance of over a mile without touching the earth, and "flew" as high as sixty feet above it.

lift a man into the air, so much strength has it. Taking Professor Bell's idea, the late Professor Langley, of the Smithsonian Institution at Washington, designed a flying-machine with three or four wings made up of kite-cells of the tetrahedral form. This made a flight over the Potomac River but fell into the water and was ruined.



STEERING AN AIR-SHIP UPWARD BY SHIFTING THE MAN'S WEIGHT ALONG THE CAR-FRAME.

It was not long before many other inventors tried to excel the achievement of Santos-Dumont, but for a considerable while no machine was made that would remain in the air more than a short time. Of the great developments that later came we shall tell you in a separate chapter following this.

A simple explanation of "dirigible" is contained in the word "steerable." The dirigible

aeronaut or navigator. It is just as much of a balloon as those which rose above the earth in the days when the great bags were driven here and there before the air-currents, and a man who chanced to be in the "basket" or perhaps hanging on the trapeze-bar had no control over them except to open the gas-valve and lower himself by allowing the contents of the bag to escape. The shape of the bag, however, has been greatly al-



TWO AIR-SHIPS STARTING FOR A RACE.

balloon, which is what most people mean when they say air-ship, is simply a balloon which can be directed—its movements guided and controlled so that it travels in the direction desired by the

tered. It is usually in the form of a huge cylinder, narrowing gradually to a blunt point at each end, the greatest thickness of the cylinder being over the machinery. The reason why the bag of

the modern balloon is shaped like a cigar or banana is because it offers less resistance to the air when moving in a horizontal direction. Sometimes three or four smaller bags are attached to the rear end or what the seaman would call the stern. The great French bag called "La Patrie" was of this pattern, as it was believed that the smaller bags aided to steady the larger one when in motion, and permitted the steersman to guide it more accurately with the rudder.

Running this sort of an air-ship is very much like running an automobile, except that the navigator must keep his craft far enough aloft as well as headed in the right direction; but by moving enough weight beneath the back part of the bag he can throw the front end at an upward incline and thus ascend as he goes forward. If he wants to descend he can reverse the position of the weight or release some of the gas by opening the valve in the bag. Should he wish to



Photograph by Underwood & Underwood, N. Y.

THE TRIAL ASCENT OF THE AIR-SHIP "DIRIGIBLE II" IN ENGLAND.

Below the gas-bag, however, are many different contrivances. Of course there is the engine, possibly two or three, if the air-craft is very large. The basket in which aeronauts of former days usually ascended is replaced by a car which may be partly inclosed in glass as a protection from the weather. A narrow platform extending beneath the center of the bag allows the navigator to reach his engine and his ballast-bags hanging in rows in the rigging, and from this platform he may move the huge rudder by means of the ropes or wires which extend from it to the platform.

ascend vertically, he can do like the old-time aeronaut—throw over the sand-bags. The engine depends on the size of the balloon, which is usually large enough to hold it in the air with the passengers, even should it break down or stop from some other cause. It may be of five or ten or more horse-power, but it is always sufficiently powerful to whirl the big wooden, canvas, or aluminium blades of the propeller which, fastened underneath the rear of the bag, does the same duty in the air that the screw of the ocean liner does far beneath the surface of the sea. With its assistance the air-ship may travel at a

rate of twenty miles an hour or more, even against the wind.

The most successful dirigible balloon was probably the "Zeppelin," so called from its inventor. It was by far the greatest air-ship, if it may be

purposes. The one designed in England is called "Nulli Secundus," and after being completed made a trip from Farnborough, where it was constructed, to the city of London, circling around several towers in the city and finally re-



COUNT ZEPPELIN'S EARLIER AIR-SHIP, MORE THAN 400 FEET LONG.

Photographed in flight by E. Frankl, Berlin.

termed such, yet constructed, while it had a record for attaining the greatest speed and lifting the heaviest load yet borne aloft. Count Zeppelin is a German officer who has spent several years in studying the problem of air navigation. His air-ship, which was built on the shore of Lake Constance, Switzerland, was about 420 feet long and was driven by two engines having the combined power of no less than 170 horses, while the great bag contained when filled 375,000 cubic feet of gas. This air-ship in its trials rose to a height of over 1000 feet above Lake Constance, carrying not only the machinery, but twelve passengers, and while in the air moved forward at a rate of over thirty miles an hour, the navigator turning it in circles and guiding it as easily as the motorist guides his touring-car on the ground. While this craft met with an accident and was destroyed shortly after its construction, another of the same model was completed which excelled its performances.

Several of the European countries have designed dirigible balloons to be used for military

turning to its starting-point. "La Patrie," the French air-craft, also made several journeys of the same length guided without difficulty, but, unfortunately, broke from its fastenings and was carried out to sea some time ago. The United States has several types of war balloons and has recently asked inventors to plan air-ships which can be used for military purposes. American genius, however, has been successful in building models which are as practical as any of the European types.

A recent writer, looking forward to the future making and using of flying-machines, observes that there will no doubt be many improvements in them, once men have agreed that aeroplanes are the best means of sailing in the air. The machines, he says, will no doubt be made smaller than they have been, and all sorts of things will be done to enable them to carry as many passengers as possible, and to come easily to rest at stations. And even while this writer was saying these things, great progress was being made in the directions that he pointed out.

HOW A BALLOON IS SENT UP

SHOWN BY A SET OF PHOTOGRAPHS "TAKEN ON THE SPOT."



UNROLLING THE BAG OF THE GREAT BALLOON.



STRETCHING THE FABRIC OUTWARD FROM THE VALVE-HOLE IN THE CENTER.



WALKING ON THE BALLOON TO GET TO THE VALVE-HOLE. THE AERONAUT CAREFULLY LAYS A STRIP BEFORE HIM TO PROTECT THE FABRIC FROM BEING TORN OR INJURED BY HIS SHOES.



SCREWING THE VALVE-RINGS TOGETHER ON THE FABRIC.



STRETCHING THE NETTING OVER THE BIG BAG. THE GAS TO FILL THE BALLOON IS TO BE FED FROM THE GAS-RESERVOIR NEAR BY.



AS THE BALLOON BEGINS TO FILL, SAND-BAGS ARE PLACED ALL AROUND AT THE EDGE OF THE CORDAGE.



THE GAS IS FILLING THE BALLOON SLOWLY. THE VALVE IS SHOWN NEAR THE TOP.



AS THE BAG FILLS, MEN WALK AROUND THE BALLOON SHIFTING THE BAGS TO LOWER LOOPS OF THE CORDAGE.



UNLESS THE CORDAGE IS KEPT TIGHT BY THE SAND-BAGS ALL THE TIME THE BALLOON IS FILLING, THE SLACK ROPES WILL ALLOW IT TO BE BLOWN ABOUT BY THE WIND.



THE BALLOON AS HERE SHOWN, IS ABOUT HALF FILLED.



IT BEGINS TO LOOK LIKE A BALLOON—WILL BE FILLED IN HALF AN HOUR.



THE MEN PULL IN THE CORDAGE AT THE BOTTOM, PREPARING TO ASCEND THE BASKET.



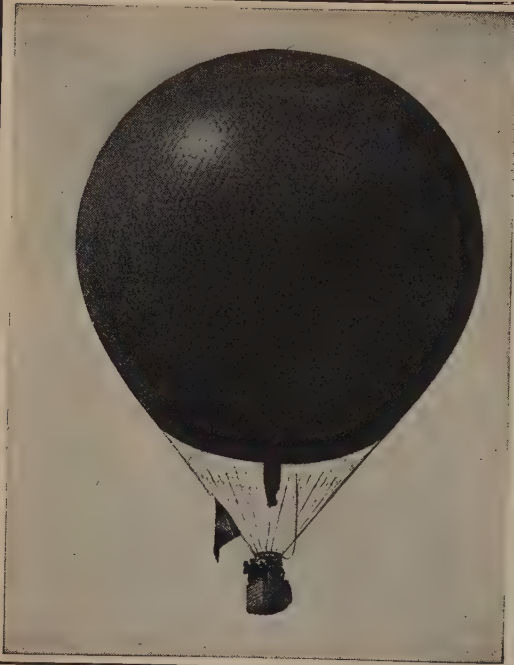
STILL PULLING IN THE CORDAGE TO NARROW IT DOWN TO THE BASKET. THIS PICTURE GIVES A GOOD VIEW OF THE FILLING-PIPE OF THE BALLOON THROUGH WHICH THE GAS IS POURING INTO IT.



WHEN THE BALLOON IS FULL OF GAS, THE SAND-BAGS ARE SHIFTED TO THE LEADERS AND PULLED IN TO THE BASKET SHOWN IN THE CENTER.



ALL ABOARD, AND OFF!

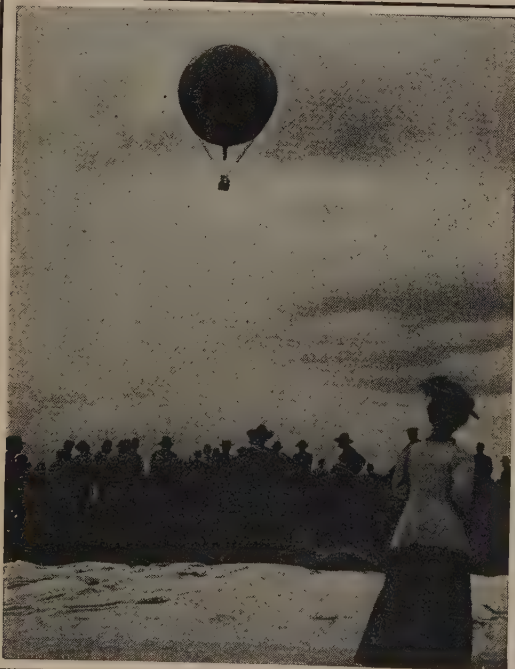


STILL GOING UP—UP—UP!

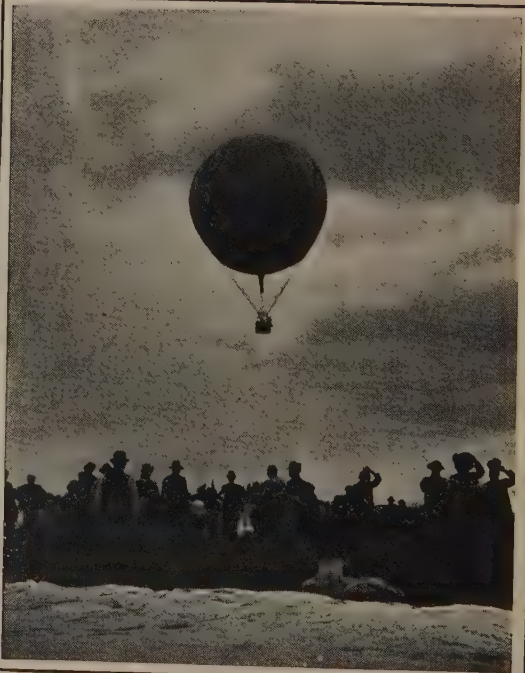


A FEW MINUTES LATER.

COMING DOWN.



ALMOST DOWN!



"HERE SHE COMES!"

ABOUT FLYING-MACHINES

BY TUDOR JENKS

How quickly the art of flying became a reality! We all knew that the scientific men were trying experiments, and we all hoped that we might live long enough to see flying a reality; and then one day came the news that "two brothers out West" had really made a long flight in a machine of their own invention. The news was doubted at first, but the reports were so quickly verified that doubt gave place to an eager curiosity to know what the new machines were like. When we saw pictures of the new flying-machine, it proved not so very different from a well-known type; but in the small difference was the reason for success—for the machine *was* a success, and showed men how they might at last gain dominion over the air. And so, in the year 1903, the long seeking for a flying-machine led to the first that was built on true principles.

Now let us see how the conquest of the air was won.

That men have always wished to fly we may know from their giving wings to all superior beings; angelic messengers, fairies, demons, witches receive the power of flight as a matter of course. And, wishing to fly, it was certain that men would at first study the habits of birds, and would argue as Darius Green did:

"What 's the use of wings to a bumblebee
Fur to git a livin' with, more 'n to me—
Ain't my business
Important 's his'n is?"

Certainly it looks easy, when one sees the "swallows skim along the smooth lake's level brim"; and for a long, long time men thought that if they had wings like the dove, of course larger and stronger, they could at least make a beginning. So many tried the experiment. It was not hard to build a pair of wings "of leather or of something or other," or even two pairs; and many kinds were made—so many that the most ingenious of boys with the best sort of tool-box probably could not invent a new variety even if he worked all summer.

Some of these early wing-makers lived in the shadowy days of history. Bladud, a British king, was one; but all that we learn of his flight is that he soared above his city of Trinovante, and then fell upon a temple, thereby ending his wings and himself. Bladud belonged to an unlucky family, being the father of Shakespeare's "King Lear." Simon, called "the magician," who lived about

the time of the Emperor Nero, lost his life in the same way; another martyr to the science was a monk called Elmer (or Oliver) of Malmesbury, who had foretold the invasion of William the Conqueror, and was therefore taunted by cruel people when he did not know beforehand that he would break his legs on taking flight from a tall tower. This monk is said to have flown 125 paces. People laughed at him all the more when he said that he failed because he did not fix a tail to his feet; but a recent writer, Chanute, argues that the monk was very likely right in his conclusion.

A hundred years later, and more, a Saracen repeated the attempt, and, like poor Oliver, was killed. Then we read of a relative of the poet Dante, who made a successful flight over a lake, and fell in trying to repeat the feat across a square in the city of Perugia—though even upon this second attempt he is said to have "balanced himself a long time in the air," and to have fallen only when his wings broke.

We do not know what wings these men had, but from later facts it seems likely that the stories told of them are true. We know nowadays that with stiff wings men can often sail long distances, and such flights as are reported seem to have been made with fixed wings and from high places.

After men became more skilled in the making of machinery, they tried to make moving wings; but it was found that the moving wings would not raise men from the ground.

Leonardo da Vinci, being a great architect and engineer, as well as painter and sculptor, left note-books proving that he had studied the flight of birds, and had planned flying-machines to be driven by wings or by screw-propellers. But as Leonardo was good at figures, he seems to have abandoned his plans after finding out how much power would be needed.

A French locksmith thought that practice was the great thing; and, fitted with wings, he jumped first from a chair, and afterward from a window, and then from the roof of a small house. In the last experiment he sailed over a cottage roof, but soon after sold his wings to a peddler—and probably saved his own life. Another Frenchman, a marquis, tried to go by the air-route across the river Seine; but he was not drowned; since a washerwoman's boat happened to be where he came down.

From those early days until recently, inventors



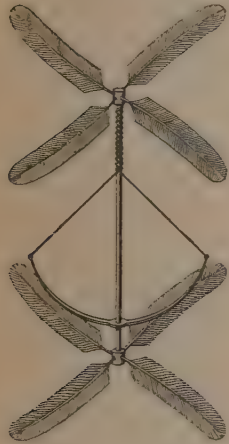
NEW YORK SKY HARBOR IN 1950.

UP THE MAIN AIR-SHIP CHANNEL.

A peep into the future through the eyes of Arthur T. Merrick, an artist.

kept on building large wings and small wings, driven in every sort of flapping, by legs and by arms; but it is useless to quote the long list of failures. They proved only this: A man is not strong enough to flap wings big enough to hold him up; and man's muscles move too slowly to flap wings as fast as a small bird can.

All well-instructed inventors of to-day know that in order to fly with flapping wings man must have some far greater power than his muscles. Many light motors have been tried in the form of models. The principal ones—explosive compounds, steam, electricity, springs, and rubber bands—have been reasonably successful when the models were small enough.



AN EARLY MODEL.

The subject of flying models is interesting, but it will be possible here to describe only a few that will serve to show the different kinds used before successful aeroplanes.

One of the earliest was made by putting four feathers into a cork so as to make a propeller. Two of these propellers with feathers sloping in opposite ways were set on a stick, one propeller being fixed, the other revolving. A bow of whalebone was attached so that its cord could be twisted around the stick. Upon winding up the cord, and then letting it go, the model would be driven upward.

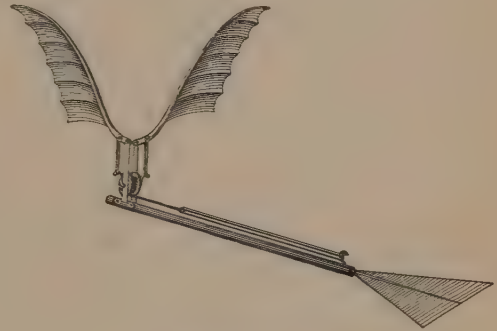
A drawing will make this clearer. The whalebone-bow is pierced to let a wire through, and works easily on it. The rod is jointed at the bow, and the upper propeller turns from right to left, the lower in the other direction; but the feathers are so sloped that both sets tend to move upward. This model is described because it is not hard to make, and will fly pretty well. To make the upper rod movable, that part may be a hollow stick put on a wire fixed into the lower part.

A simpler model on the same principle is the one known as Pénau's "Hélicoptère," or, in English, "screw-wing," the invention of a clever young Frenchman who made some of the best models, though he worked only a short time on the subject, and died when he was thirty.

It is the simplest form of the flying-screw, and is moved by a twisted rubber band. It is wound up by turning the lower wings, or propeller, and when released flies in the same way as the one in the picture. A common Japanese toy some-

times found in toy-shops illustrates this principle. It is an imitation butterfly that will fly as high as the roof of an ordinary house.

These two forms will show how the screw-models work. Those driven by flapping wings may be more briefly described, for they do not fly so well and are harder to make. The least complicated ones were made by Jobert and Pénau. In Jobert's a stretched rubber band pulls a cord and revolves a pulley. The pulley turns two little cranks that move the wings up and down. Pénau's model works on a similar plan. In both the wings are stiffened by a rod along the front edge, while the rear edges are



JOBERT'S MODEL.



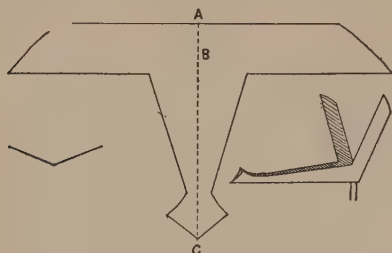
PÉNAUD'S MODEL.

flexible; so the wing slides forward on the air as it descends.

A third sort of model shows the aeroplane method of flight, that led to success in making real flying-machines. This new method uses flat or curved surfaces, sliding quickly upon the air, to support the weight. Scale a card through the air, and it travels upon the air, holding itself up so long as it has momentum.

In order to see just how aeroplanes act, take a piece of writing-paper, about eight inches long

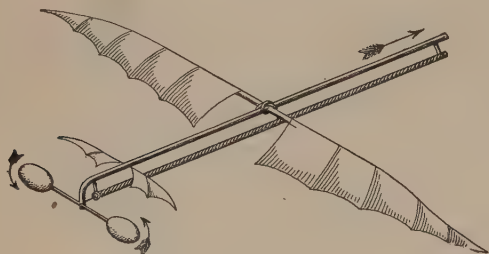
and four inches wide, and cut from it a paper bird like this:



PAPER AEROPLANE.

Then bend it along the line AC into a flat V, putting two pins at B, as near the head as you conveniently can. Now stand on a chair and drop the bird, and it will come down as if it were a hawk after a chick. The weight of the pins pulls it down, the wings resist by pressure against the air, and the paper bird *slides* down instead of falling direct.

When the wings are sloped a little upward at the forward edge, and the planes are pushed forward by a propeller, they rise on the air. To illustrate how aeroplanes may be caused to rise, here is an early model made by the Pénau al-ready mentioned:



PÉNAUD'S AEROPLANE MODEL.

The little wings at the rear are set at a greater angle than the large wings; and whenever the front begins to droop, they resist more, and thus bring the head upward again. They do this the more easily because the front wings lose some power whenever they are nearer level.

A simple diagram will show how these rudder-wings act.

The model is made heaviest at the head, C. If it begins to go downward, as at 2, the rudder-wings at A come more directly against the wind and pull back, raising the head; the wings B, meanwhile, are edgewise to the air, and offer little resistance, so the model goes faster. When the model rises, as at 3, the rudder-wings are flat, and stop lifting, while the wings at B push

against the air, and slow down the flight until the weighted head comes level again.

The result is that this model flies in a wavy line, up and down, like a sparrow.

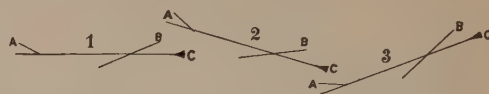


DIAGRAM SHOWING ACTION OF RUDDER-WINGS.

This aeroplane contained valuable hints for future inventors; and modern inventors used the same method to control the earlier flying-machines.

Many of the little models fly excellently; but to make the machines big enough to carry men, new difficulties have been overcome. Big machines cannot be driven by twisted rubber bands, or, if they could, the flight would be no safer than if the machines were fired out of cannons, like the projectile in which Jules Verne's heroes made their imaginary "Trip from the Earth to the Moon." And when any machine fell, it would be smashed to smithereens—together with its passengers. A toy may be allowed to fly into the air, and then fall to the ground; but a flying-machine must not only rise, but must keep right side up while on its voyage, and must then descend safely.

Consequently the prudent air-ship maker must in all cases provide, first, enough power to carry his ship aloft and drive it where he chooses, in anything short of a hurricane; second, a method of balancing securely while aloft; third, a method of coming down in safety.

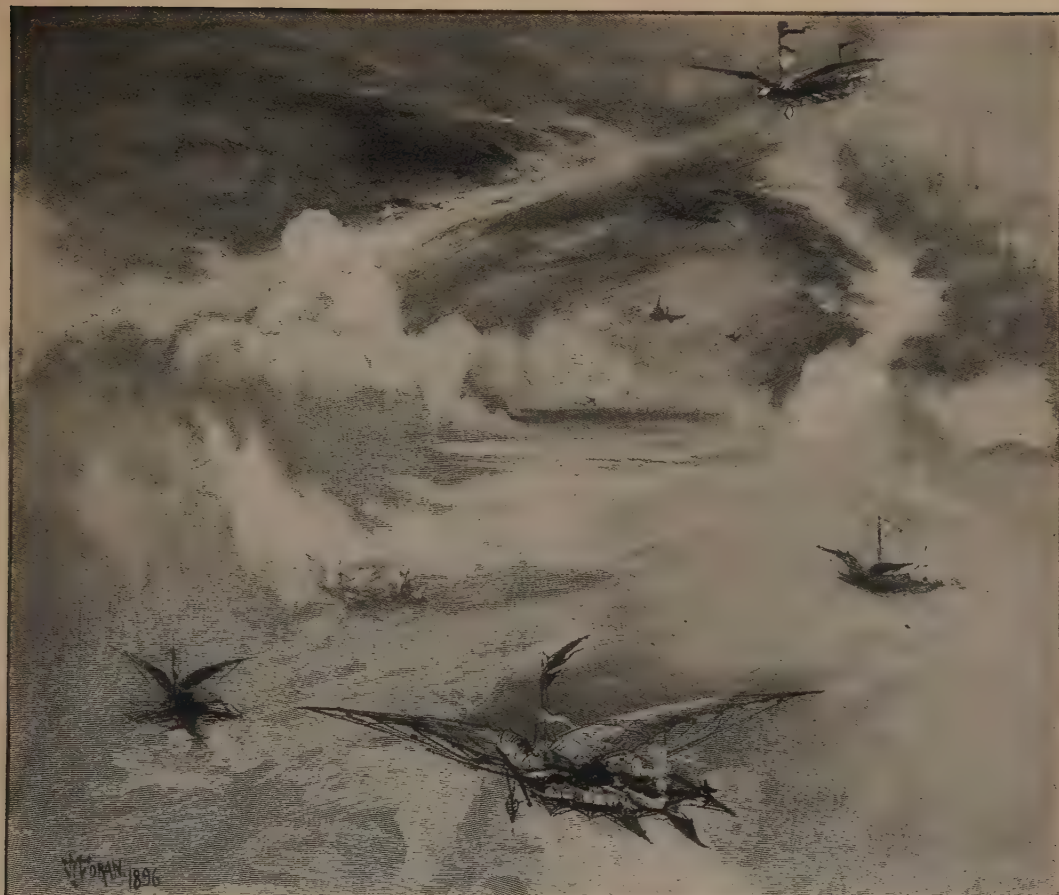
Of all means for lifting and driving the air-ships—balloons, wings, screw-propellers, and



ONE OF MAXIM'S STEAM-ENGINES.

aeroplanes—it has been decided that the planes are the best supports, and by their use was the problem solved.

And this decision was no piece of guesswork. Careful experiments were made, especially by two Americans—Samuel P. Langley and Hiram Maxim—both learned men, and both well in-



WHAT YOU MAY SEE ON SOME FINE DAY IN THE FUTURE.

formed about all that had been done before our own times with all sorts of flying-devices, to determine just what form of aeroplanes was best worth trying. Their experiments were made separately.

There was a number from which to choose, for men had tried to fly with planes as with every other apparatus. A model aeroplane was made that flew fairly well, and the design was patented in 1842 by Henson; but he never made a large machine.

Du Temple made trial of a similar plan, but all known engines were too heavy for it—even though this inventor and his brother seem to be the first who made their boiler of light tubes, as is the present method with steam-engines. In 1875 an English enthusiast named Moy built a large air-ship driven by screws and held up by planes. It was run around a circular track, being fastened by a rope to a pillar, but did not make speed enough to rise from the ground. Lack of power, which came partly from lack of

money, perhaps, kept Moy from making an air-voyage.

Only a word or two more can be spared to these inventors, clever as many were. Each added some useful fact to what was known before him. Thus Wenham, in 1866, showed that planes could usefully be put over one another; Brown, in 1873, that planes at the two ends of a rod would balance well; then came Moy, already spoken of, and Tatin, who made a model that flew in a circular track, which Moy's machine failed to do. In 1879 Dandrieux, a Frenchman, made a model much like the Japanese toy already spoken of—a paper butterfly driven by twisted rubber. A similar model with undulating wings was made by Brearey, who added an elastic cord extending from the under side of one wing to that of the other. This made the down pressure stronger, and gave better flight.

These machines, and many others, made the task easier for inventors who came afterward, by showing which experiments promised the best

results; and their experiences gave Maxim courage to make his flying-machine on a large scale.

Langley and Maxim began as modern men of science do—each made trials of all sorts to find what material and what shape would give best results; and Maxim built and tried every kind of motor that suited his purpose. He tried engines moved by hot air, oil, steam, or electricity; and at last convinced himself that the steam-engine was the easiest to manage, and gave nearly as much power for its weight as any motor. The gas-engines were not perfected till later.

While Professor Langley made less outward show than Mr. Maxim, perhaps it will be found that his experiments and writing did as much for the art.

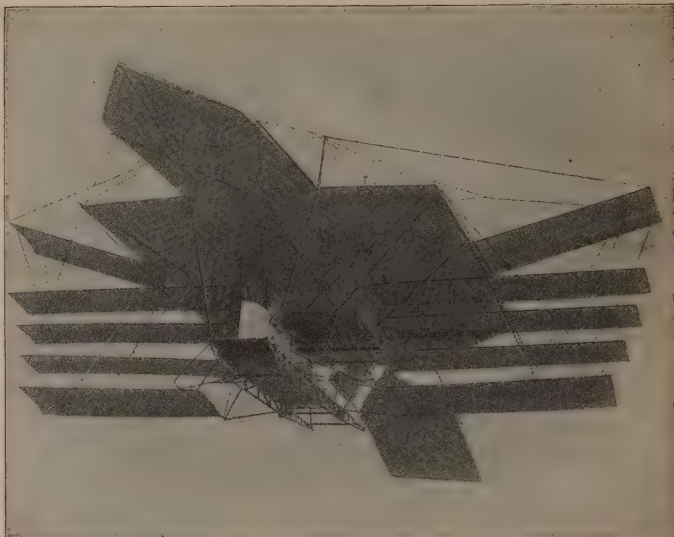
Scientific men thought that if an engine could be made weighing less than forty pounds for each horse-power, flying-machines could lift it and themselves by its aid. Now, by using light tubes to make his boiler (the same plan is adopted in torpedo-boats), Maxim constructed the two lightest engines then built. Weighing only 640 pounds together, they gave 360 horse-power—much more than was thought necessary for flying. For their weight these engines were nearly five times as powerful as those Moy had tried, though Moy's were considered a marvel of lightness and power in 1875. The rapid advance in modern science is shown by this improvement in less than twenty years.

The engine being ready, Maxim tested different fabrics until he had found out the best material for making the aeroplanes—his bird's-wings. The tests were made on an ingenious little machine that showed how much each piece of stuff would lift, and how hard it tried to go with the current of air blown against it.

He found that an aeroplane made of a special kind of cloth called "balloon fabric" would, with the same weight and power, carry more than any balloon could lift.

Then Maxim went to work on a large air-ship to be driven by screws and supported by planes. The body of the machine was a platform car on wheels. The car, forty feet long and eight feet wide, carried the two little engines. Above were the aeroplanes of cloth, stretched by wires upon a framework, the largest being fifty by forty feet, and capable alone of lifting most of the weight. It was meant also to make the machine fall

slowly, for it would act as a parachute in falling. At the sides were smaller planes, and in front and behind were planes movable up and down—rudders to steer upward or downward.



MAXIM'S AEROPLANE OF 1893, AS IT WOULD APPEAR IN THE AIR.

The machine ran along its own railroad, a track a third of a mile long, and could be driven by the push of its air-screws as fast as most locomotives.

The inventor soon found that when the car ran at a high speed it tried to rise from the track; so he built guard-rails above to keep his flying-machine down. You see that Maxim did not intend to go up until he had made sure of keeping his balance and coming safely down.

The air-ship and its appliances were finished in 1893, the engine being so arranged as to use naphtha for fuel, and to condense its own steam into water, so that it could be used over and over.

All these matters required time, labor, and money—to say nothing of the brain-work—and over \$50,000 was spent before the air-ship began its trips along the rails.

Then the inventor began his lessons in flying, taking careful notes of the machine's behavior at different rates of speed. It was soon proved that when three quarters of the power was used, three of the car-wheels left the lower track, and at full speed the whole machine ran on the upper track, free from the ground. It was also found that the side-planes would keep the air-ship from rolling over, and that the action of the fore and aft rudders promised to be satisfactory.

When the whole machine was in the best of



WARFARE IN THE AIR, AS IMAGINED BY A GERMAN ARTIST.

order, it was run at a speed of thirty-seven miles an hour. The planes lifted all four wheels and the machine ran upon the *upper* track for some

So much for the aeroplane up to the year 1893. Meanwhile another sort of flight has been attempted, and to some extent successfully, by other inventors. This is the soaring or sailing flight. You may see it in operation almost anywhere if you will keep an eye upon the gulls, hawks, eagles, and other soaring birds. Yet it was long doubted whether any bird could sail in the air with motionless wings. Nowadays the evidence that such flight is not only possible but usual is overwhelming.

Maxim believed, and it is now known, that birds are aided in this soaring by the many minor currents in the air, of which the bird takes full advantage.

Chănute, in his book "Progress in Flying-Machines," shrewdly remarked that stories about men flying successfully have come

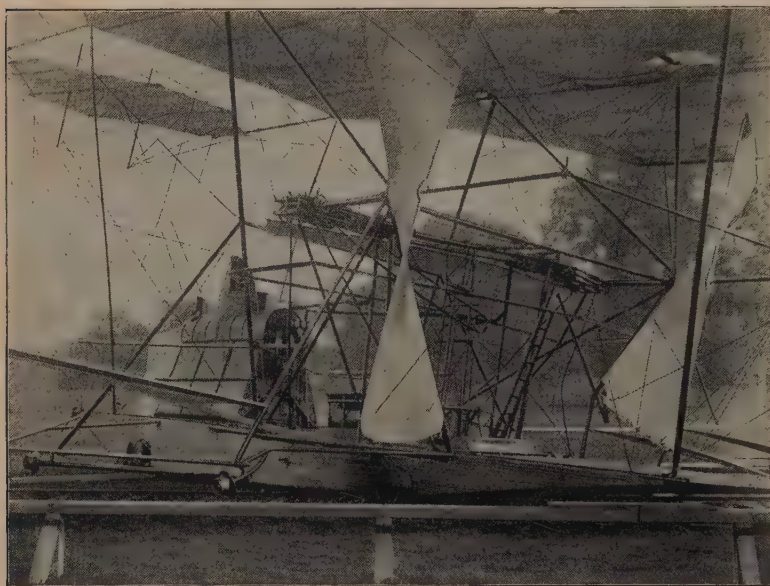
almost entirely from the warm countries—the regions where steady winds make soaring birds a

distance. But the lifting-power was too great. An axletree of one of the rear upper wheels was bent—the air-ship was set free and the front wheels broke the guard-rail. Steam was shut off and the ship dropped.

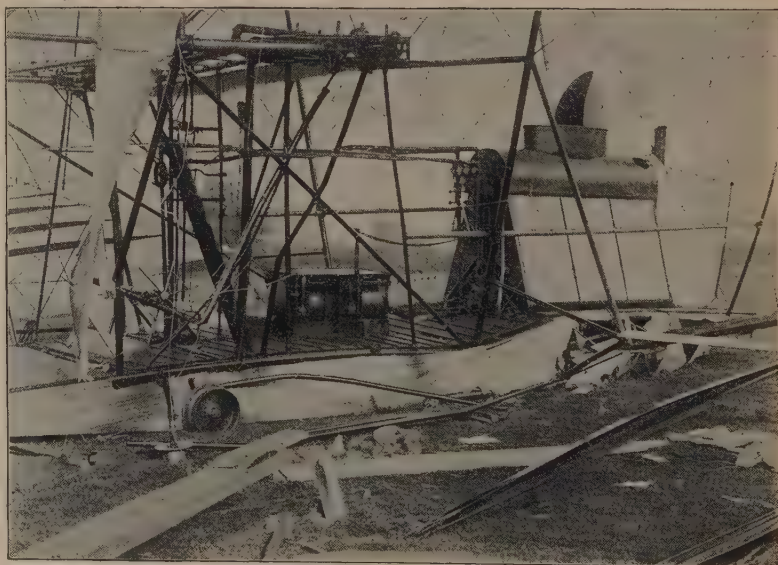
The broken rail did some damage; but the ship was repaired, and Maxim at all events had made a very helpful experiment.

Here is Mr. Maxim's opinion upon the result:

Had it been known twenty years ago that a machine could be made on the aeroplane system which would really lift its own weight, its fuel, and its engineer, we should have had plenty of flying-machines in the world to-day. If one half the money, time, and the talent which has been employed by the French balloon corps in their fruitless efforts to construct a navigable balloon should now be employed in the right direction, the whole question of aerial navigation would soon be so perfected that flying-machines would be as common as torpedo-boats and the whole system of modern warfare would be completely changed.



VIEW OF THE PORT SIDE OF THE MACHINE AFTER THE ACCIDENT.
Showing the axletree which, by bending, led to the accident.



THE STARBOARD SIDE AFTER THE ACCIDENT.

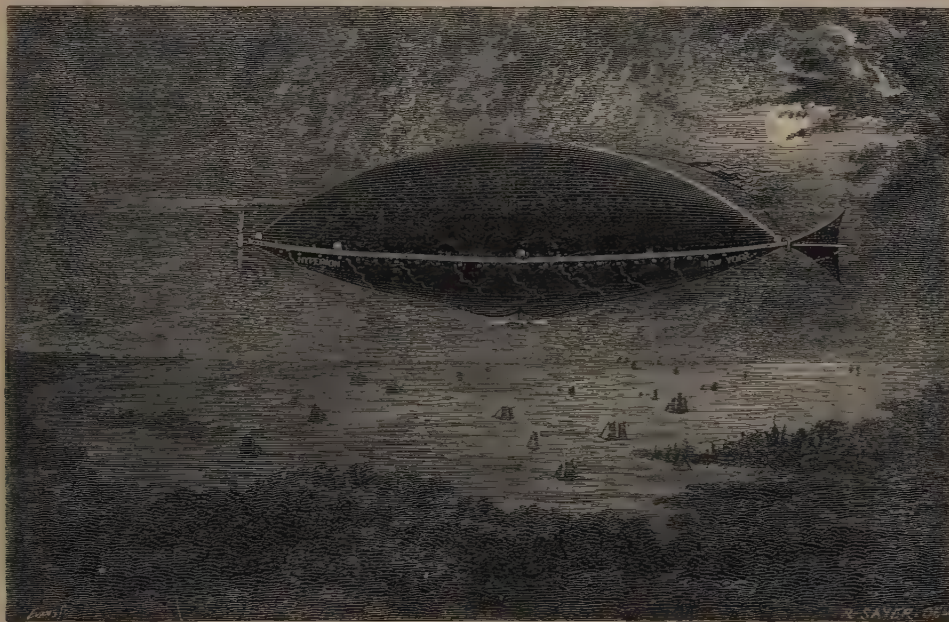
common sight. His book told nearly all the experiments in flying in which men depended on their own strength.

Among the most striking instances of flying are the experiments made many years ago by a Frenchman named Le Bris.

Le Bris once held up in the breeze a wing he had taken from an albatross, and, he says, "in spite of me it drew forward into the wind." He wondered if he could make wings that would act in the same way, and about 1855 he built a bird-like boat with outstretched wings that could be moved slightly by rods. Then he placed the machine upon a cart, got into it, and told the driver to drive against the wind. When they started

bits. With a second air-ship he once went up forty feet, and he flew the same vessel loaded with ballast even higher. When this second air-ship was smashed, Le Bris gave up, for he was a poor man and could not afford another.

These flights were *against* the wind, and proved that surfaces curved in a certain way were drawn forward "into the wind's eye," as sailors express it. This fact was explained in a book written in 1864, and its author, D'Esterno, was laughed at and considered out of his head because he claimed that flight was possible with a machine built to



AN IMAGINARY AIR-SHIP OF THE BALLOON TYPE.

Le Bris kept the front edges of the wings bent downward; but soon the horse began to trot, Le Bris raised the front of the wings, and behold! up went the boat until (so he said) it was higher than the church steeples, and floating along *against the wind*.

But soon Le Bris heard energetic remarks in the air below him, and found that the driver had been caught in the rope and was then dangling down like the tail to a kite. So Le Bris turned the wings so as to glide downward until the driver was on solid ground, and could run after the runaway horse and cart.

Le Bris tried to return to the upper air, but failed; and he came down unhurt, having only slightly injured the machine.

The air-boat-being repaired, Le Bris soon made another start; but this time he had Humpty Dumpty's luck and the machine was smashed to

soar rather than fly—that is, without power to drive it, and with motionless rather than with flapping wings.

The same belief was urged in "L'Empire de l'Air" by Mouillard, a book on the flight of birds. Mouillard claimed that, after a start, a bird can rise without motion of the wings provided the wind is strong enough. The author built such wings, and tried them by leaping at a narrow ditch. Up he went, and then glided 138 feet before he came down and broke a wing. A second trial was successful also, except that in coming down he sprained his shoulder.

And still later a number of "human birds" repeated and varied these trials. Although great feats have not yet been done, it looks as if the chief trouble is lack of practice. One of the best known and most skilful fliers was a German named Lilienthal, who, after years of study and

trials, made in the summer of 1891 a pair of wings curved like a great bird's. As the result of his studies and experiments, he believed curved surfaces better than flat planes—in which he "agreed with Le Bris, Goupil, and Phillips, other students of the subject. All these men believed that the curved shape of birds' wings has much to do with their flying, helping them to go against the wind—a strange effect which the French have named "aspiration." To-day this has been established by many proofs.

Provided, then, with wings and tail, Lilienthal began to practise, at first upon a spring-board, and afterward in a hilly region near Berlin.

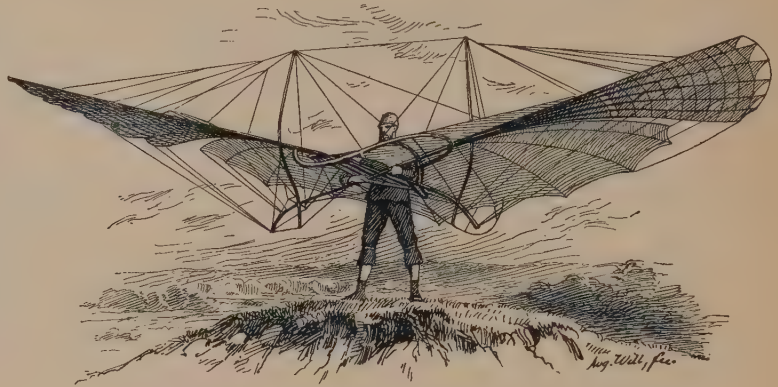
Even after he was able to sail as far as eighty feet, he found that it was best to arrange the wings so that they could be easily thrown off; otherwise, he coolly says, "I might have had a broken neck instead of sprains which always healed in a few weeks."

In 1892 he made larger wings, and learned to sail farther than before, rising twenty or thirty feet from the ground upon a favoring wind. But in 1896, during one of his bold feats of soaring, Lilienthal lost control of his apparatus and was killed—a martyr to the science of flying, and a helper toward success.

Some Americans also during this period were at work with wings, among them A. M. Herring of New York, who was said by a paper to be "experimenting with wing-surfaces large enough

danger—Pilcher bent his wing-tips at the ends. These experiments contain a hint of the device that the Wright brothers afterward used.

There were other experimenters at work, on



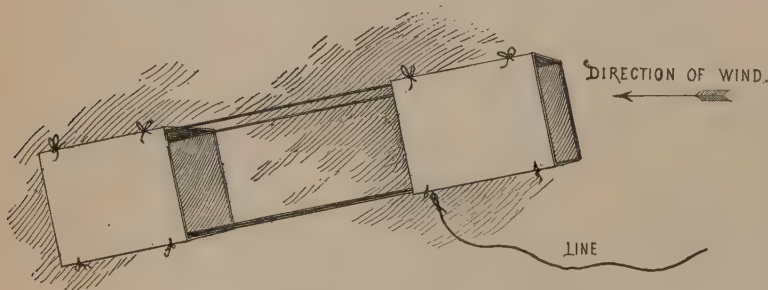
OTTO LILIENTHAL ABOUT TO TAKE FLIGHT IN HIS GLIDER.

different lines, in various parts of the world, but none yet more successful. Lawrence Hargrave of New South Wales made a great number of simple and successful models—one being driven by compressed air, and flying over 300 feet. He next gave his attention to kites; and in November, 1894, made one that carried him up along a string, and brought him safely down. Meanwhile other experimenters carried on the work, among them Wilbur and Orville Wright, of Dayton, Ohio, who discovered many valuable principles. They used a flat plane in front for steering up or down, and invented a safe means of balancing by bending the ends of the main aeroplane surfaces as found necessary—a true Yankee invention, and one that gave the flier control of the machine.

By 1905, using a gas-engine, they made many successful flights—one of nearly twenty-five miles, which was covered in half an hour. The problem was solved, the flying-machine was a reality, and thenceforward the rapid advance of improvement becomes bewildering.

Aeroplanes of all shapes and plans became possible by reason of the invention of the gasoline-engine. Santos-Dumont, Henry Farman,

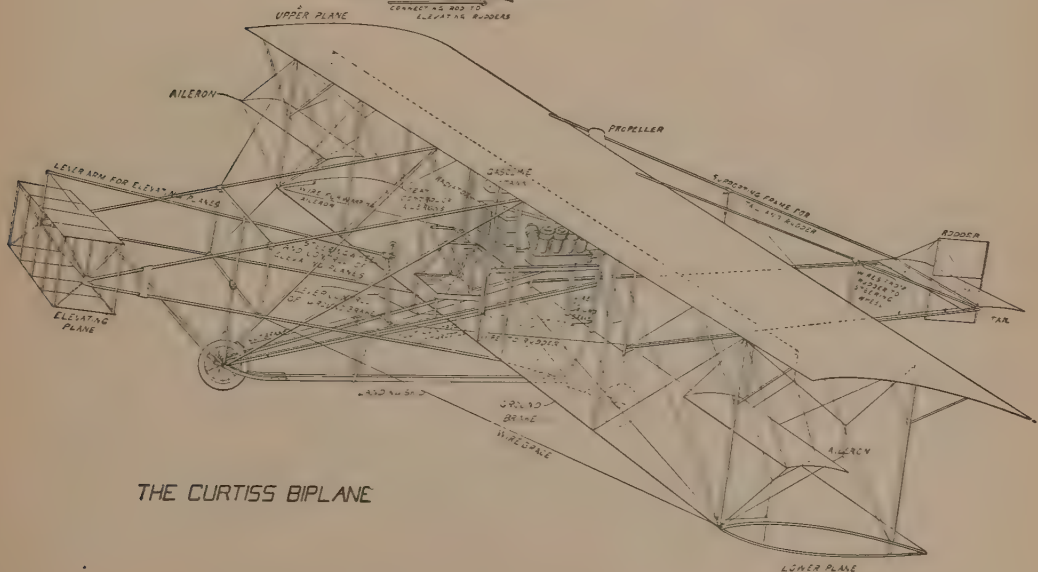
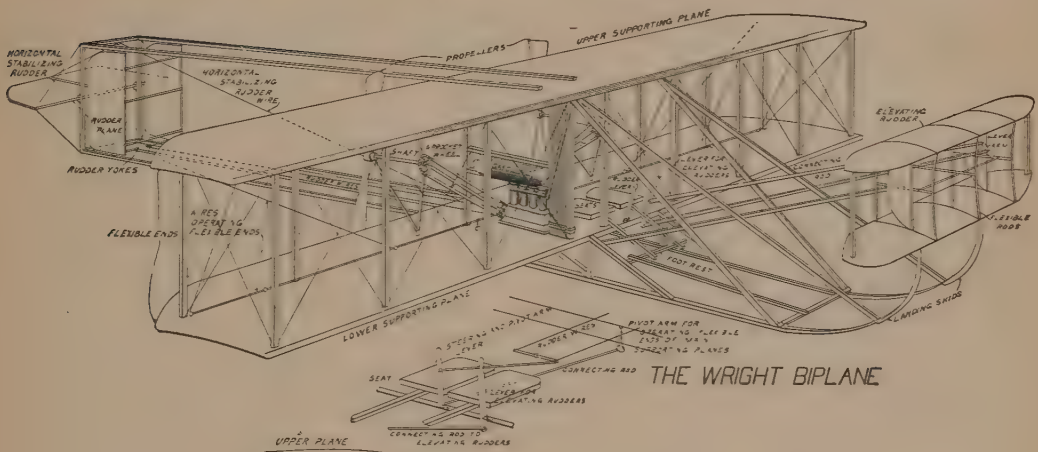
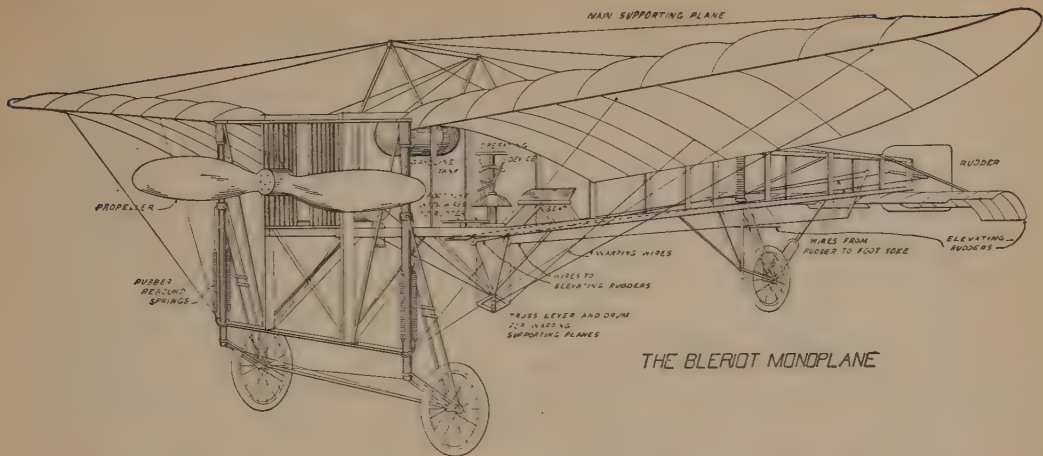
Delagrangé, and especially the Wright brothers, made many long flights, remaining in the air longer and longer, and learning the management of their machines. By December of 1908 Wilbur Wright made a flight lasting over two hours.



A KITE ON HARGRAVE'S PRINCIPLE.

to carry his own weight for over a year!" Herring succeeded in sailing 300 feet.

In 1895 Mr. Pilcher, of Glasgow, made flights with wings not unlike Lilienthal's; but to guard against being upset by sudden gusts—a constant



THREE TYPES OF SUCCESSFUL FLYING-MACHINES.

But, now, before going on with the history of the flying-machine, let us see what its invention was expected to accomplish.

"The air will be the ocean; or, rather, let us say, that ethereal ocean, the atmosphere, at last having been utilized and made available for the commerce, the travel, the swift running to and fro of men, every spot of this globe will be a building-site, every acre a harbor, every open space, plain, hummock, the highest range, the humblest valley, an aerial port. . . .

"The change will be gradual. The art of aerial navigation will be slow of perfection. Our primitive vessels and motors will be rude and defective, as Stephenson's locomotive now would seem to us. Heavy freights must long continue to move by water and rail. Aerobats at first will be used for the transmission of the mails and light express packages, and especially for their swift conveyance over sea. Soon the inland companies will have each its own 'aerial express.' By and by aerobats displaying the insignia and pennons of the great newspapers will leave town at 3 A.M., and whirl over the country 'as the crow flies,' and at their utmost speed, dropping their packages in the towns and villages along the routes in every direction of the compass. Soon the more adventurous and resolute, and finally all classes of travelers, will avail themselves of the great passenger aerobats and enjoy the unsurpassable luxury of flight, experiencing thrills of wonder and ecstasy, and a sense of power, freedom, and safety to which all former delights of travel may well seem tame by comparison. . . .

"In every way the resources of social life will be so enlarged that at last it truly may be said, 'Existence is itself a joy.' Sports and recreations will be strangely multiplied. Rich and poor alike will make of travel an every-day delight, the former in their private aerobats, the latter in large and multifarious structures, corresponding in use to the excursion-boats of our rivers and harbors, the 'floating palaces' of the people, and far more numerous and splendid. The ends of the earth, its rarest places, will be visited by all. The sportsman can change at pleasure from the woods and waters of the North, the run-ways of the deer, the haunts of the salmon, to the pursuit of the tiger in the jungle or the emu in the Australian bush. An entirely new profession—that of airmanship—will be thoroughly organized, employing a countless army of trained officers and 'airmen.' The adventurous and well-to-do will have their pleasure-yachts of the air, and take hazardous and delightful cruises. Their vessels will differ from the cumbrous aerobats intended for freight and emigrant business, will be chris-

tened with beautiful and suggestive names—Iris, Aurora, Hebe, Ganymede, Hermes, Ariel, and the like—and will vie with one another in grace, readiness, and speed."

So wrote the poet Edmund Clarence Stedman in an article for the "Century Magazine," as long ago as the year 1879. And to-day we see the beginnings of all that he so wisely prophesied.

In 1909 the French aviator Blériot crossed the English Channel, and Henry Farman stayed in the air more than four hours. By this time there were so many airmen that aviation meets were held in many large cities, at which successful flights were hourly exhibited. In 1910 long flights were taken, one being that of Paulhan from London to Manchester with but one stop. This won a prize of \$50,000 and was a marvelous feat for its day, though now so far exceeded.

The flights of 1909 and 1910 were no longer the mere experiments of the previous years; the later fliers made actual journeys in the air without waiting for fine weather; they flew over the sea, or over fields and towns, and they carried not only small packages, but even a passenger or two, and they went at great speed, covering as much as 50 to 150 miles. Various feats were performed, such as going thousands of feet upward, and flying from the deck of a battle-ship to the shore. Of course there were some tragedies; but, considering the novelty of the feats and the number of ascents, these were not many—far fewer than have been met with in the use of the motor-car, for example. And that the aeroplane was considered likely to be of use in war is shown by the fact that the practical French had sixty of them in 1910.

But the rate of progress in 1911 cast that of the previous year into the shade. Feats once thought extraordinary were then hardly noted in the day's news. Exhibitions were held in nearly all civilized lands, and hundreds of schools taught the art of flying to all who cared to pay the fees. Papers and magazines gave place to the experiences of "birdmen," factories began to make aeroplanes and all the needed supplies for the new art, and thousands enjoyed the sensation of flying in some two hundred varied types of machines.

The newer things in the year's progress were the coming of the "hydroplane," a craft that would rise from the water into the air, and then descend to the surface on which it had floated; and the revival of the attempt to fly in a "glider," or aeroplane without a motor. This last feat, performed by one of the Wrights, resulted in a flight 225 feet high for over ten minutes in a gale blowing some 50 miles an hour.

Though thousands of flights might be men-

tioned, it will be enough to record the journey of the American Rodgers, who flew from New York to Los Angeles, over four thousand miles, in three days and ten hours of actual flight, going at the rate of over fifty miles an hour. Of course we are counting only the time *in air*, for he took many days on the way, being injured at one time, and compelled to rest for weeks. Early in 1912 Rodgers fell with his machine and was killed, as so many aviators have been, in this country and others—costly sacrifices to the advancement of aerial enterprise.

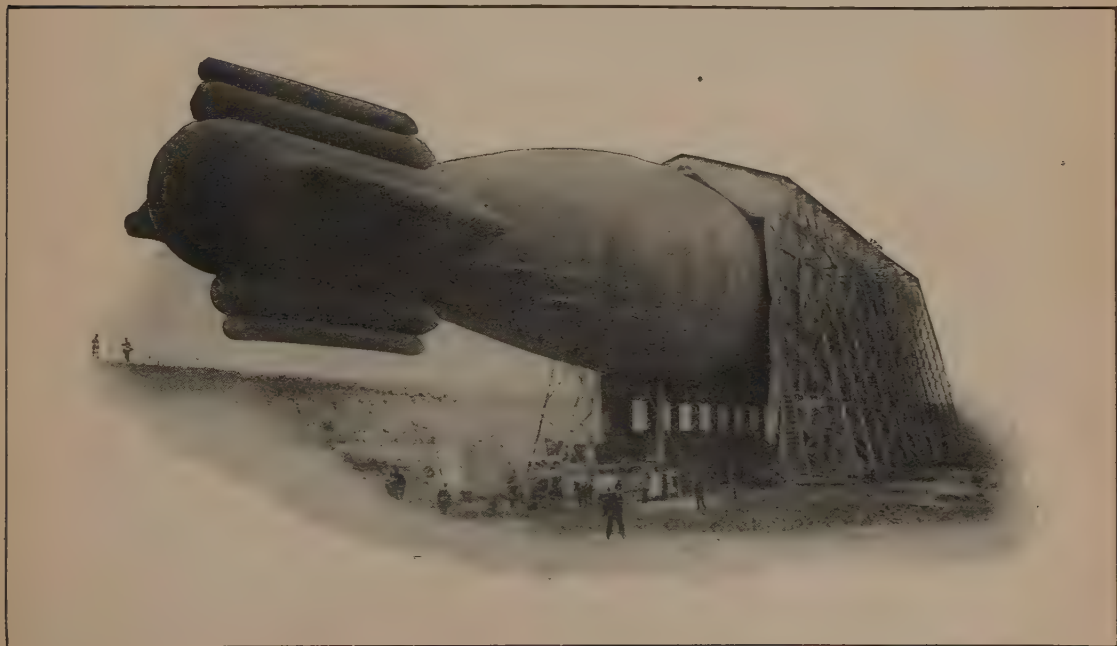
Other notable facts were the carrying of mail, and the successful flight from shore to a war-ship and return. There were many exciting races, many remarkable journeys, and a number of trials to learn what uses can be made of the aeroplane in war and peace.

But though this article tells mainly about the real flying-machine rather than balloons, yet when we speak of its use in war, we must say a little about the balloon type of flier, for this has now been so improved that the aeroplane is not likely to be of use in war except as an aid to the enormous cigar-shaped vessels, from 500 to 700 feet in length, and able to carry not only supplies and passengers, but even quick-fire guns, bombs, and plenty of ammunition. Thus loaded, they can travel quite as fast as any aeroplane large enough

to attack the dirigible balloons, and by the aid of the rifled guns can easily protect themselves if they choose to fight. These big balloons will no doubt be the "battle-ships" of the air, and may, as many think, make warfare so uncertain and so destructive that their use will be forbidden by the nations of the world—just as explosive bullets are not allowed. Yet at present the great nations are building these balloon navies in large numbers. The experiments already made with them show that they become safer as they are made bigger, and they already carry passengers on regular trips in Germany.

The air-ships are here, and we begin to see what they will mean to the world. They will make it possible to explore all parts of the earth; they will go anywhere without need for road-making; they will cross deserts, or fly over the loftiest mountain-peaks; they will carry mails faster than the quickest express-trains; they will afford a new sport; they will create a new sort of literature; they may make it nearly possible to stop smuggling; and it is hoped that they may put an end to war.

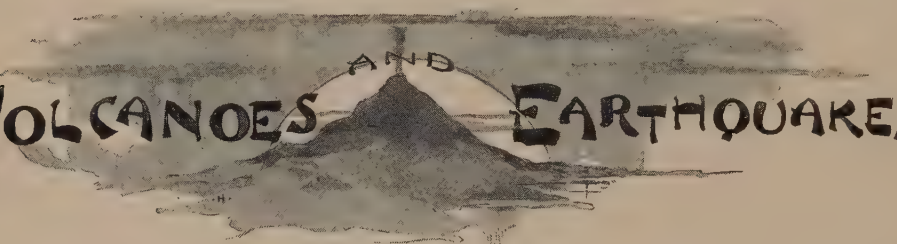
Whatever the future may bring, the world can never again be the same as before men learned to fly, and the young people of to-day will at least see a world that contains what King Solomon could not find—"something new under the sun."



"LA VILLE DE PARIS," THE DIRIGIBLE MADE BY HENRI DEUTSCH.

MARVELS OF EARTH AND OCEAN

VOLCANOES AND EARTHQUAKES



I

BY MRS. CHARLES F. HARTT

ASTRONOMERS tell us that once upon a time the earth was melted throughout, as the sun perhaps is to-day; but in the lapse of ages the outside of it cooled down until a crust formed all over its surface. This is the "solid ground" on which we live, and we shall presently see that it is not so solid as it appears. Scientific men differ as to the exact thickness of this crust, but a majority believe that it cannot be greater in proportion to the diameter of the earth than the thickness of an egg-shell to the mass of an egg.

Now it is true that the depth reached by the deepest mines is but trifling in comparison with the thickness of this crust, yet it is sufficient to enable us to prove the law that the deeper we penetrate the earth the hotter it grows, and at the rate of about one degree for every ninety feet of descent. Artesian wells bored to a depth of two or three thousand feet always bring up warm water, and hot springs often appear to come from still greater depths.

It seems rather appalling, but, according to this reasoning, at a depth of about twenty miles the rocks must be red-hot, and, a little farther inside, everything must be melted; and this ocean of lava is the foundation on which rest the "everlasting hills," as we often call them.

It would take too long to tell you how the crust

of the earth has risen and sunk on this molten sea—lifting its surface above the ocean to form land, and sinking away down under water; how it has crumpled up like the skin of a drying apple, only that the crumplings were hundreds or thousands of feet high and sometimes extended thousands of miles, forming mountain-chains. You will learn all this by and by, when you study geology. What you need to know now, in order to understand how volcanoes are formed, is the fact that this crust has cracked through from time to time with immense cracks, some of which have extended for hundreds of miles.

If lava were only melted rock, it might be thrown out with less noise, but it is full of intensely heated water and gases of various kinds tremendously compressed. Now it may be a new idea to some of my young readers, that water may be made extremely hot and yet not boil. If you put some water in a tea-kettle and set it on the stove, you must heat it up to 212 degrees Fahrenheit before it will boil, and it will not get any hotter, no matter how fierce you may make the fire beneath it.

If some water is put in a strong vessel corked tight, it will be found that the steam which is formed and cannot escape presses on the water, and it may be heated much above 212 degrees without boiling; but if the pressure be suddenly removed, the water flashes into steam, and there is a tremendous explosion.

When I was a child, I corked up some water, one day, in a stout vial, and set it on a stove. Wondering why it did not boil, and not knowing any better, I at last took out the stopper, when it exploded, driving out the contents of the bottle. I narrowly escaped a scalding.

The water had been too much heated, and of course as soon as the pressure was taken off, it flashed into steam. Precisely what happened to the water in the bottle, happens in a volcanic eruption. As the melted rock with the imprisoned water and gases comes up toward the surface of the earth, and the pressure grows less, it at last reaches a point where the water instantly changes into steam. Then, in the crevice in which this takes place, the steam and liberated gases blow out everything before them, straight up into the air with a puff of smoke and steam, and a noise to which a cannon is but a pop-gun. Great rocks are sometimes torn off from below and hurled miles into the air, and sometimes the lava, liquid as water and exceedingly brilliant, is spouted up like a fountain to a height of several

thousand feet. The explosions are sometimes so terrible that tracts of land a mile square are blown bodily into the air. Of course when so great a quantity of loose stuff is thrown out of the earth, it must be piled up in a huge heap or mountain, which slopes off in every direction from the opening. This is always kept clear by explosion, so as to form a great gulf like a funnel in the top of the mountain. The gulf or funnel is called the "crater." A crater may be very large, as for instance that of Kilauea in the Hawaiian Islands, which is two miles long, a mile wide, and 800 feet deep, with a constantly boiling lake of fire at the bottom.

Let any reader who wishes to form some idea of a stream of lava go to see an iron-furnace when the iron is being drawn. The melted metal, so bright that it blinds the eye, spouts out from the opening in the furnace, and rapidly runs down like water into the channels made in the sand to receive it; but the farther it goes the cooler it gets. It soon becomes sticky and covered with scum, and by and by it only creeps along. So the



CRATER OF KILAUEA, HAWAIIAN ISLANDS.

lava soon cools, the surface "rises" like yeast, and becomes spongy and hard, and cracks up, and, at a distance from the source, the lava-stream looks like a river of furnace-clinkers moving slowly along, the fragments on the surface rolling over one another with a rattling noise.

There are volcanoes all over the world. They occur all along the Pacific coast, on the western side as well as the eastern, all the way from Bering Strait to New Zealand. There are volcanoes in Africa, in the Mediterranean, the West Indies, and even amid the eternal ice and snows that surround the southern pole. Iceland is especially noted for its volcanoes, which have burst forth from time to time in the most fearful eruptions. On one occasion the volcano of Skaptar Jökull poured out a stream of lava which, flowing into the bed of a river, dried it up. The flowing lava followed the bed of the river until it came to a lake, which it filled up, and, soon after, it reached a tremendous abyss over which a magnificent waterfall had formerly plunged. Here, too, the lava took the place of water, and formed a cataract of fire which must have been a grand and awful sight.

Of course all volcanoes are not of the same age. Many have been formed within the last few centuries, and we have descriptions of several from eye-witnesses who watched their formation.

About the middle of the eighteenth century, on

the elevated plain of Malpais, in Mexico, lived a planter by the name of Jorullo (pronounced Ho-rool'yo). All had gone along quietly enough in that neighborhood up to June, 1759, when, under the plain, were heard terrible subterranean noises. Then earthquakes followed, and continued for two months, and presently the ground burst open, a terrific eruption took place, and a volcano was formed upon Señor Jorullo's plantation. When Humboldt visited the spot about forty years afterward, he found, in addition to the principal volcano, an immense number of little oven-like vents scattered over the plain, and still hot and smoking.

Just to the north of Naples in Italy is the beautiful bay of Baia, on which anciently stood a little town called Tripergola. In the years 1537 and 1538 a great many earthquakes were felt in the vicinity, but on the afternoon of Sunday, the 29th of September, 1538, fire burst out of the ground, ashes, mud, and stones were hurled out, and, in a single night, a volcanic mountain 440 feet high was thrown up, very near the town. Its fires speedily died out; the Italians call it Monte Nuovo, or the New Mountain.

Tremendous eruptions may take place from a volcano without an accompanying earthquake, and the vicinity of an active volcano may be one of comparative safety, so far as earthquakes are concerned. If you throw a stone into a pond you know that a circular wave, or several such waves,



VOLCANO FORMED ON SEÑOR JORULLO'S PLANTATION, MEXICO, IN 1759.

are formed, which extend in every direction, disturbing the whole surface of the pond. If anything is floating on the water, as, for instance, a chip, when the wave reaches the object, it rises and falls for a moment, and then it becomes quiet in the same place. Similar waves may be formed in iron or wood or rock. When a heavy train is passing, you know how the ground jars and shakes, even at a considerable distance. This is because waves are formed in the ground like those formed in the water when disturbed by the fall of a stone. Now if, owing to some disturbance below, the rock-crust of the earth should suddenly rise or fall or be shaken, waves would start off with tremendous rapidity in every direc-

shores to a height far above that reached during the severest storms. Earthquake-waves following earthquakes have done terrible damage to cities and settlements on the shores of Chile and Peru, the Hawaiian Islands, the West Indies, and in various other parts of the world. They show what mighty force is in the earthquake.

II

BY PROFESSOR FREDERICK D. CHESTER

It may be asked, why do we speak of volcanoes and earthquakes in the same breath? I answer, because the two are as closely related as a boiler and its safety-valve. After the great earthquake of July, 1883, upon the island of Ischia, in the Mediterranean, Mount Vesuvius, which lay just across the Bay of Naples, began to smoke and discharge lava. The same thing occurs after nearly every earthquake, if there is a volcano near by. The earthquake comes first, and then the volcano sends out its steam with a hissing, growling noise, very much as steam escapes from



MONTE NUOVO, ITALY, FORMED DURING A SINGLE NIGHT IN 1538.

tion. When these waves pass under a place they jar or shake it, more or less severely, causing an earthquake or earth-tremble. Some of these waves in the rock are several feet high, and as they move at the rate of from thirteen to eighty miles in a minute, when they pass under a town it may be shaken down or tossed up, like the men on a chess-board when one gives it a rap underneath; and in the twinkling of an eye the largest buildings may be overthrown. Sometimes the earth jumps up beneath the feet, sometimes it sinks suddenly down, and sometimes the motion is from side to side, so that trees lash the ground with their tops. There is something inexpressibly dreadful about an earthquake. There is the sudden subterranean thunder, then the violent shaking of the earth, the crash of falling buildings, and the cries of affrighted men, women, and children rushing hither and thither for safety. But where is safety to be found when the earth itself is rocking?

Earthquakes sometimes disturb the sea and cause the formation of immense waves, which pass across entire oceans and break upon the

the safety-valve of a boiler. Now, a safety-valve is for the purpose of relieving the boiler when there is danger of its bursting because of an excess of steam-pressure. For similar reasons, when there is too much steam in the earth, there is danger of an explosion, and in all real earthquakes the ground quakes, heaves, and splits because of these explosive shocks, until the volcano opens its valves. Then the earthquake ceases. So the volcano is the safety-valve of an earthquake.

Geographies sometimes tell us that a volcano is a mountain from which issue smoke and flame; but this is not correct. When you see pictures of dark, curling pillars or clouds of what appears to be smoke pouring out of a mountain, be assured it is not smoke, but steam darkened by the flying ashes. The mountain in the picture may look as if it would burn down in a few hours; but this is only an appearance. In reality, the red-hot melted rock or lava is lighting up the clouds of steam, so that they resemble flames of fire. If you have ever seen the fireman of a locomotive open the fire-door at night, you may remember how the

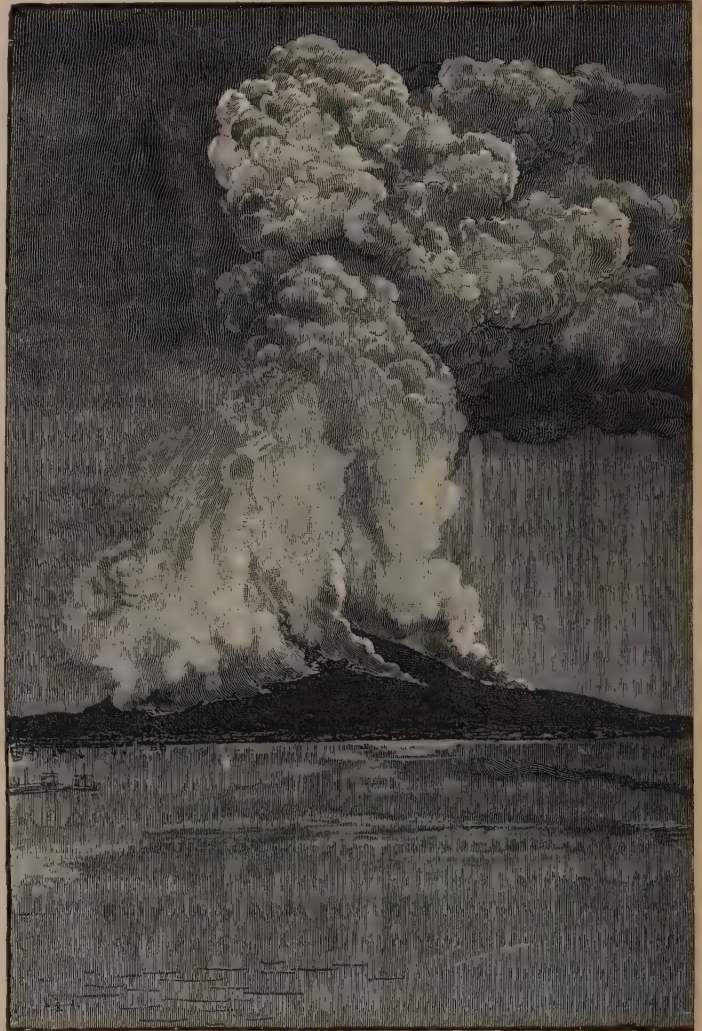
steam was illuminated until the whole engine seemed ablaze. This will make you understand why active volcanoes appear to be burning.

But a volcano also throws out immense masses of stones, ashes, cinders, and lava. Imagine a single volcano pouring out at one time enough of all these things to make a pile as large as three Mont Blancs!—or another throwing out enough material at a single explosion to cover all of Germany two feet deep!

Now, let us consider how so much rock gets melted, and whence so much steam comes. You know, even if you have never tried it, that it takes a great deal of heat to melt a rock; as much as it takes to melt iron and copper. Many rocks can hardly be melted. The hardest way to melt a rock is to dry it in an oven, and then put it in a furnace. But there is another way to do it, whereby it requires but one quarter as hot a fire. A piece of cold lava, such as may have been brought from some volcano as a specimen, is broken up fine, and mixed with water until a stiff mud is formed. Then a strong steel tube, closed at one end, is filled with the mud, after which the other end also is closed, and the whole put into the fire. Experiment has proved that the mud thus confined will not require nearly so hot a fire to melt the particles of rock, as would be necessary if the latter were dry. But, you say, how can this be?—for wet things resist the action of heat better than dry. The explanation is probably this: the water in the mud which you put in the thick steel tube changes, when heated, into steam, and this steam, having no means of escape, is under great pressure. While ordinary steam, such as comes out of the spout of a tea-kettle, is very hot, and is capable of dissolving rocks very slowly, steam which is under great pressure, as in the tube, becomes much hotter, and has therefore greater power to dissolve substances. Considering this, we can see why the steam confined in the tube should easily dissolve some of the rock, and that a portion of it being thus dissolved, the remainder would more easily become liquid, just as the melting of a small portion of butter hastens the melting of the rest. We shall find that rocks which lie deep

under the ground are melted in much the same way as are the particles of lava in the tube, but with this difference, that the water in the former case is under such pressure that none of it can ever turn into steam.

You may ask why the water is under so great



VESUVIUS IN ERUPTION. (BY PERMISSION, FROM
"THE NEW ASTRONOMY," BY PROFESSOR S. P. LANGLEY.)

a pressure. You must remember that where the rocks are melted is at a depth of at least four or five miles, and that all water in the rocks at this depth would therefore be pressed upon by rocks four or five miles in thickness. If you consider what a pressure is brought to bear upon the lowest stone of a great tower by the stones above, you will better understand why water at great depths is so confined that it cannot become

steam. If you were to go down into a mine, you would find that the deeper you penetrated, the hotter it would be. In one great mine in Nevada the air is so hot that it is necessary to pump down cold air so that men may work in it. Deeper still, it probably is hot enough to melt the rocks.

But there is another fact to be learned. When it rains, some of the water soaks into the earth and through the rocks, by different ways, until it reaches hundreds and thousands of feet below the surface. So much is found in some deep mines that it would require many fire-engines to pump it all out as fast as it comes in.

We are now prepared to learn more about volcanoes. A volcano is often declared to be a mountain; but this is not always the case. We learn from geology that most of the ancient volcanoes, before men were created, were not mountains at all, but merely cracks in the ground, from which proceeded steam, melted rock, and other matter. But if an opening in the ground keeps pouring out melted rock, it makes a vast accumulation of lava about the crack, until it may build up a real mountain. As the steam always tries to escape upward through the fissure it forces the lava up with it until the crater is full, and looks like a lake of fire, or a great kettle of red-hot slag. Just before the volcano pours out the melted rock, it often acts as you may have seen porridge do when it is cooking on the stove. The porridge gurgles and bubbles, and the surface heaves as jets of steam escape. It then sinks, and rises again a little higher than before, until, if you continue the heating, the porridge may rise so high that it boils over and runs down the sides of the kettle. The porridge gurgles, bubbles, and heaves because the steam is trying to escape into the air; and, as the steam seeks the air through a great lake of lava, the latter bubbles, gurgles, and heaves, just as the porridge does, until it boils over and runs down the sides of the mountain like a river of fire. Besides the noise made by the boiling lava just before an eruption, there are sometimes all sorts of other terrible sounds heard. The steam often escapes with a deafening hiss, as if many locomotives had opened their valves at once; and again, it has such power that stones, cinders, hot lava, and sometimes even pieces of the mountain, are thrown far into the air, to fall again with a tremendous rattling noise.

It is a well-known fact that the action of volcanoes is not continuous. Generally the crater is in a hardened condition, from the cooling of the lava, and steam is emitted only in places where the lava melts again. But after slumbering for years, the awful thing will suddenly awake anew, and pour out a flood of fire.

What is the cause of this period of inaction? The steam has been exhausted, and a period of eight or ten years or more may elapse before the earth can again have absorbed sufficient water to make steam enough for sending out the lava.

We are now ready to speak of the earthquakes, and discover, so far as we may, how they are caused and what they are. I have already mentioned the dreadful earthquake of July, 1883, that occurred upon the little island of Ischia, fifteen miles across the bay from Naples. It was nearly ten o'clock on a Saturday night. The week's work was done. The fishermen had drawn up their boats on the beach, and were in their homes.



A VESSEL LEFT FAR INLAND AFTER THE PASSING OF AN EARTHQUAKE WAVE.

Hundreds of picturesque hotels and cottages nestled peacefully amid the tropical foliage. The hotels were thronged with visitors, and the theater was crowded.

Suddenly a tremendous shock was felt, and a sound heard like the thundering of a train over a bridge. Two more shocks followed, and all was over. In the space of fifteen seconds three towns had been destroyed and thousands of people had lost their lives. And yet this shocking occurrence

by no means equals some similar calamities where far larger tracts of country and cities with tens of thousands of inhabitants have suffered.

We have already said that an earthquake takes place when there is too much steam under the ground; but remember that it is a sudden explosion, and not slow

how apple-skins wrinkle when they are baked; that is because the apple under the skin shrinks when the juice cooks out; as the skin does not contract as fast as the apple, it wrinkles when it is brought closer together. Now, the earth is not unlike the apple: there is the outer crust, which corresponds to the



A STEAMER BORNE ASHORE BY AN EARTH-QUAKE-WAVE.

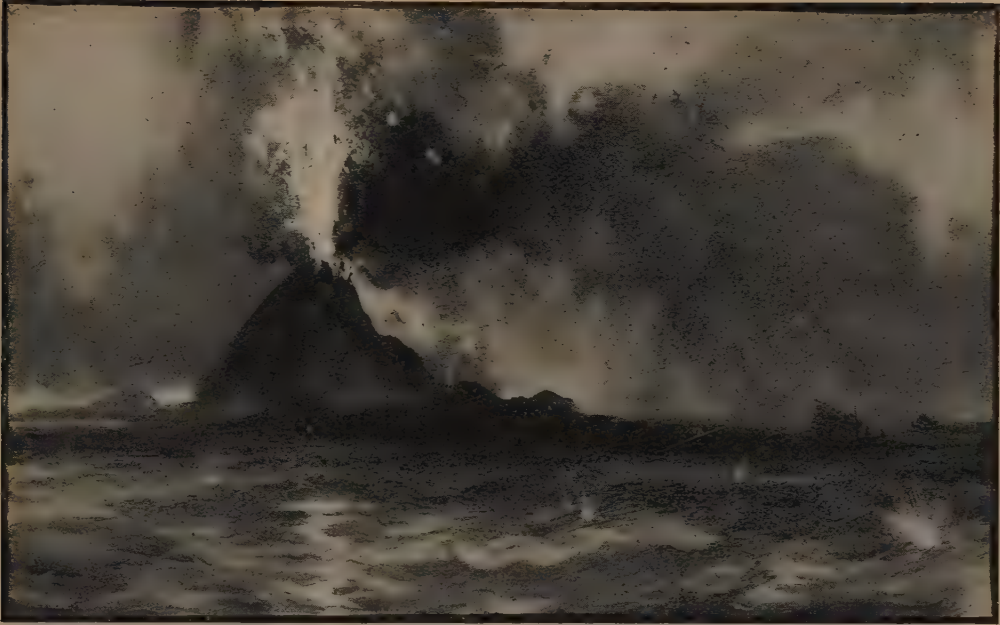
upward pressure. Supposing there were a hundred boilers, or more, buried four or five miles beneath the surface of the earth, and that they should all burst: we should have a result similar to an earthquake. The ground would shake, heave, subside, and even crack open in great fissures. You would hear a noise which might be low and muffled, like thunder, or a sound like that of the earthquake at Ischia.

Again, the crust of the earth is not wholly stable, but continually rises and sinks; this country, for instance, subsided eight or ten miles during one epoch of geological time. Not only is the crust subjected to a great *downward* pressure, as a result of its enormous weight, but also to a still greater pressure from the sides. You know

skin, and there is the inner earth, which corresponds to the apple. As the inner earth tends to contract faster than the crust, the latter tends to wrinkle. But as the crust of the earth is rigid, it does not wrinkle easily and resists the great side-pressure. After the crust has withstood this side-pressure for a long time, and been at the same time pressed down very hard by its own weight, it may suddenly break with a snap, and a terrific jar is the result. In many earthquakes, the violent crash is followed by a sudden sinking of the ground, which buries whole towns. This is because the crust is broken, and sinks rapidly by its own weight.

So earthquakes may be caused in two ways: first, by the explosion of steam beneath the surface of the earth; second, by the sudden snapping of the earth's crust. Either of these, of course, would jar the surface of the earth. Sometimes it shakes back and forth, or up and down; sometimes it rocks like a cradle; but the usual effect is a trembling motion, produced as if by some great shock dealt from below.

While we usually think of earthquakes as taking place on land, they do, indeed, occur with



KRAKATOA IN ERUPTION.

equal devastation in the ocean. That point in the earth at which the explosion or breaking takes place is called the earthquake-focus; and from it what are known as earthquake-waves pass



REMAINS OF KRAKATOA AFTER THE ERUPTION.

quake-focus, with this difference, that instead of water-waves the latter produces earth-waves, passing through the ground. When the city of Lisbon, Portugal, was destroyed, the earthquake took place in the bottom of the sea, fifty miles west of the city. Yet it so agitated the water that a wave sixty feet high dashed over Lisbon, destroying it and its inhabitants in the space of six minutes. Another earthquake, occurring just off the coast of Peru, made such a gigantic wave that a large vessel was thrown several miles inland. These are called earthquake-waves. They are the largest known waves, and are caused by the heaving and rocking of the bed of the sea. In deep water such waves are not very high, but their motion extends far down into the ocean. When they reach shallower water, however, they heap up like a gigantic wall, and, with a force more terrible than fire or sword, they sweep on, bearing destruction with them. Huge ships are tossed like straws far inland, or mingle their ruin with that of a harbor town.

The terrible volcanic eruption of August, 1883, which occurred off the coast of Java, caused the sudden destruction of thirty-two thousand people, as the disastrous waves engulfed the coast, destroying the homes of the natives. If you will look at a map, you will see that the island of Java runs in a nearly east and west direction, and that it is separated from the island of Sumatra by a channel of water called the Strait of Sunda. In this strait, adjoining the west end of

to the surface. What do these earthquake-waves resemble? Take a basin full of water, and dip a glass tube in it. Blow through the tube and you will see bubbles rising to the surface, and circular waves passing out. The disturbance at the bottom of the basin corresponds with the explosion or snapping of the crust at the earth-

Java, are a number of volcanic islands, one of which is known as Krakatoa. Krakatoa, which is but a volcanic mountain rising from the sea, began to be in eruption in May, 1883.

At that time the steam escaped from the crater

ashes, and the sea, agitated by earthquake-waves, put all vessels into deadly peril.

Enveloped in the unnatural darkness, but hearing the advance of the waves, the natives on shore sought refuge in the mountains. All through

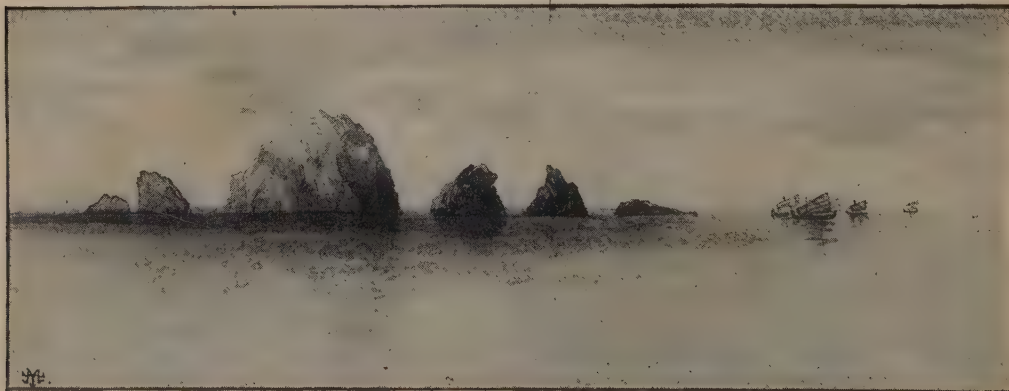


THE ISLAND "THWART THE WAY," BEFORE THE PASSING OF THE EARTHQUAKE-WAVE.

in puffs, sometimes white, sometimes gray or black with ashes, much as it does from the stack of a locomotive. Viewed from afar, this steam apparently rose to a height of thousands of feet, where, caught by currents of air, it was spread out over the mountain in a vast canopy of cloud. This, however, was but a preliminary operation. The great eruption, with its attendant earthquake-waves, did not begin until August 26. At about four o'clock in the afternoon of that day a series

the night these appalling waves were heard. Throughout the morning the rain of ashes continued, and by noon the entire coast was plunged in complete darkness.

The violence of the earthquake-waves increased, and at about two o'clock in the afternoon appeared in the neighborhood of Krakatoa the largest wave of all. Approaching the southwest coast of Java, it rose to a height of over one hundred feet, passing over and totally destroying the light-



SIX ISLETS FORMED FROM THE ISLAND "THWART THE WAY," AFTER THE EARTHQUAKE.
(FROM SKETCHES BY CAPTAIN JOSEPH T. CONANT.)

of reports, like the firing of heavy cannon, were heard proceeding from Krakatoa. These reports, becoming louder and louder, continued until night, when a thunder-storm, accompanied by a high wind, arose. The air was thick with falling

house of Anjer, a tower 151 feet high, besides overwhelming many towns.

The same great earthquake-wave passed over a neighboring island known as "Thwart the way" and converted it into six rocky islets.

THE WORLD IN THE WATERS

We know that all life began in the sea, but life did not leave the sea forever. There is still more life in the depths of the ocean than on the land. The sea teems with unnumbered forms of life—life as simple as that which first swam in the waters, and life as wonderful as that of the whales and dolphins and seals. There are fishes that sail through the air so high above the water that we call them flying-fishes. There are fishes that can crawl out of the water and walk overland. There are fishes that build nests at the bottom of the sea, creatures that build islands and sea-walls; and in cliffs and mountains we find myriads of skeletons of tiny creatures that once lived and breathed on the ocean-bed.

Not the wisest men on earth know the full story of the sea and its wonders. How can they? They have to seek knowledge from the things that their dredges bring up. That is as if we set to work to examine some great, deep lake by bringing up things from its depths in a teaspoon. However, patient work is constantly bringing new learning to us. We know that there is no place in the ocean where life is not possible. The waters of the equatorial regions and the seas of the temperate zone abound with life, and so also do the silent waters of the frozen arctic circle.

Nature will have no blank spaces. There is a place for everything, and we find everything in its place. We find, swimming upon the surface, creatures that cannot go far down into the ocean. In the middle depths we find fish that cannot come to the surface lest, without the proper pressure of water upon their bodies, they should burst. Those same creatures cannot descend below a certain level; and still lower down are creatures that never see the light, fulfilling in the unlit depths of ocean the purpose for which they were created.

For the present it will be interesting for us to glance at some of the lowest forms of life in the sea. We shall find it as wonderful as anything in the whole of Nature's fascinating story. Let us consider the marvels of that class of tiny organisms called *Infusoria*. They exist in fresh water and in the water of the sea. In a single cupful of pond-water, such as certain infusorians like, there may be more of them than there are people in the whole world. The rate at which they increase is astounding. One infusorian breaks up into two; two become four; four be-

come eight; eight become sixteen, and so on, almost as we watch.

Given the proper temperature and nourishment, a single infusorian may become in four days the ancestor of a million like itself, in six days of a billion, in seven and a half days of a hundred billions. From that tiny speck we have in seven and a half days this countless host, weighing over 200 pounds. Of course, the numbers do not work out like this, for there are merciful checks, or the whole earth and its seas would not hold the creatures that are born.

Floating upon the surface of the sea, and stacked high over its bed, are countless billions of these and similar tiny creatures, dead and living. Of what are the white walls of England, the beautiful chalk cliffs, composed? Of nothing but the shells of the tiniest little creatures, which we call *Foraminifera*. They were all living creatures millions of years ago. They were born and had their day, and they died, piles upon piles of them, and their shells turned to chalk. And other white cliffs, which will some day rise above the waters, are still being built up beneath the sea to-day. The tiny specks of life in their little shells are still being born, and are still dying, down in the sea, and they are forming ooze which will some day be solid chalk. It would take about ten millions of them to make a pound of chalk, but enough of them have lived to make millions of tons of chalk.

INSECTS THAT BUILT UP THE STONES OF PARIS AND BERLIN

SOME of the greatest European mountain ranges, the Alps and the Balkans, consist largely of the shells of little creatures like these, called nummulites. Among the greatest wonders in the world are the Sphinx and the pyramids in Egypt, built of dead nummulites. They grew in seas where there is now dry land. They formed the Arabian chain of mountains; and from these mountains men cut the great blocks of which the Sphinx and pyramids are composed. Paris is built of stone from a similar source, and Berlin stands upon foundations made up entirely of the skeletons of tiny animals.

In view of all this, we shall not be surprised to learn of the wonders of the coral-builders. These are very tiny sea-animals, which appear in their glory only in the warm waters of sunny seas.

THE LITTLE CORAL-BUILDERS THAT WORK DOWN IN THE SEA

LONG, long ago, men had been in the habit of bringing coral up from the sea in nets and by other means. The common fishermen could not be expected to know a great deal about its composition, but wise men thought they knew more, and they all agreed that coral was simply a sort of rocky flower grown in the sea. But how could a flower be hard? That was quite simple, they said. The fishermen told them that coral, when in the sea, was quite soft like any other flower, but that as soon as it reached the air it became as hard as rock. And for ages that was believed. But a man who wished to know more sent down a diver, who found, of course, that coral beneath the waves is as hard as coral above the waves. This careful investigator could not believe the word of his diver, but went down in the water to find out for himself.

We know now that the coral-builder is one of the tiny, tireless workers of the deep. The coral animals are as numerous as the stars of heaven. When born, they are quite soft, jelly-like little things. But they have the power to extract carbonate of lime from the sea-water, and to build with it the most wonderful structures to live in. As bees make honey, so the coral animals make lime, from their own food. They build homes of coral for themselves. A number of them work together, and they make their houses join by neat canals or passages. But there are many forms which the buildings take.

THE ANIMAL WALL THAT RISES FROM THE SEA-BOTTOM

SOME form the loveliest structures that look like flowers. The colors are not always the same. There are browns and blues and greens, as well as the more common pink. This coral home is not made as a bird makes its nest, not as the mud plaster in which the rhinoceros loves to bury himself in a swamp; the coral is part of the coral animal itself. It issues from the soft interior of the little animal's body, and is its stony covering.

Countless hosts of coral insects working together join their skeletons or coverings to each other. They build upward from the bottom of the sea, until they reach the top of the waves. They make great reefs or barriers in the sea where before the waves flowed unchecked. The coral insects build islands. They put a great ring of coral round a tract of water, and make a lake within the boundaries of their work. In

places where they are most numerous they quite change the character of the sea. The structures are the actual coverings of the coral insects' bodies. They become solid rock, forming dry land for thousands of miles in the sea.

We know how very difficult men, with all their skill and all their fine tools, find it to build a lighthouse in the sea, but here these tiny animals, working in the depths of the furiously tossing waves, build structures which have no likeness in the world. One of their works consists of a barrier reef along the shores of New Caledonia, 400 miles long, and another, along the northeast coast of Australia, 1000 miles in extent. As a great man points out, this means a work by these tiny creatures beside which the Great Wall of China and the pyramids of Egypt are like children's toys. The work has been going on for many ages, and it is going on to-day. Of course, the result is sometimes serious to ships, which run on to the coral reefs and are wrecked. But that should seldom happen, as we have charts of the seas to guard our sailors against wreck in such ways.

LIVING AND BUILDING AND DYING IN THE BLUE SEA

IF they do damage in this manner, the coral-builders are friends to mankind in another way—they provide homes for men where only the sea once appeared. Sea-worms of various sorts bore into the coral and loosen it, so that the waves break it up. The great waves pick up huge blocks of the loosened coral, and throw it high up on the reefs, grinding much of it to powder. Shells and sand collect and are ground up together by the action of the waves. The powdered mass collects in the crevices of the reef, and presently seeds blown from afar, or carried by the sea, or brought by birds, take root in the soil that has been slowly forming. Entire trunks of trees, that have been torn up and carried down rivers and out to sea, find a lodging here. With these trees come small animals, such as lizards and insects. Trees grow; sea-birds settle; tired land-birds, blown out to sea, take rest; and at last man comes, to find trees and fruit and birds and other forms of life. Here is a home all ready for him. But the creators of it were the myriads of coral animals, living and building and dying in the blue sea.

Growing on the coral reefs and adding to their beauty, we find a great many sea-anemones. At first we might say that these are vegetable growths. Their very name suggests it.

THE LIVING FLOWERS THAT GROW ON THE LIVING WALLS OF THE SEA

THE wood-anemone, the plant, we all know. But the anemone of the sea is an animal that can kill and eat other forms of animal life, and, by some process too mysterious for us to understand, can enter into partnership with other animals, just as birds enter into partnership with crocodiles, buffaloes, and rhinoceroses. This animal-plant or plant-animal grows in the most elaborate and gorgeous forms. A fairy wand could not create more charming pictures than the anemones present. Some of them appear to have a sense of sight, for what look like eyes appear. They depend, however, chiefly on the sense of touch for their food. They have long, sensitive feelers, which look like petals or fringe. When anything fit for an anemone to eat touches them, these feelers close like a flash upon it, and draw it down the tube leading to the anemone's stomach.

Let us watch them in a sea-aquarium. The anemone, glistening and gay, grows at the bottom of the water, or on the side of the glass, like some extraordinary fringed mushroom with its head the wrong way up. There is nothing to suggest that this is a hungry little animal. But wait.

THE ANEMONE AND THE CRAB—THE CRAB AND THE SPONGES

A LIVELY shrimp darts through the water. The tentacles of the anemone are instantly all of a quiver, ready to catch the little shrimp. The shrimp's instinct tells him what that means, and he darts away if he can. But he cannot always do so. The anemone must live and have his shrimps, or other form of food, and the tentacles close in rapidly, causing the anemone to shut up like a flower going to sleep for the night. And if the effort made is quick enough, the poor shrimp is encircled by those terrible tentacles, and drawn in to make a good meal for the hungry anemone.

There are countless anemones growing upon our seashores. Some look like rosettes, others like mushrooms with a fuzzy top. The fringe of tentacles lies widely expanded, and we should never dream how quickly they can move. Let us touch the top of the anemone with a finger. It closes at once upon our finger, and we feel that each little spike of the fringe is roughened at the end, and gives a distinct pull at our finger, like the rasped claw of some insect. They are not strong enough to take in our finger, but they

have received the necessary impulse which sets them at work. The anemone shuts up, apparently believing that it has caught a meal, and for some minutes it will not attempt to reopen.

It is a humble form of life, yet there seems so much purpose and plan about the ways of the anemone that we are bound to confess ourselves amazed and bewildered at such apparent method and skill. But the wonder only begins here. The partnerships of the anemone are the most wonderful feature of its life. Let us consider them for a moment. The hermit-crab, while a vicious, quarrelsome little rascal, has no shell to cover his tail. That is the spot which his enemies attack. His one hope in life is, therefore, to win and retain a secure covering for his unprotected tail. He and the anemone seem to come to an agreement. The anemone affords him just the cover that he needs for his tail, and he in exchange carries the anemone about on his back.

The tentacles of the anemone are toward the nippers of the crab, and when he goes in pursuit of prey, the anemone helps to kill it. The anemone has stings which paralyze or kill a little living animal. The crab has, therefore, a powerful ally to help him in killing his food, and as he eats, the anemone shares his meal. It is a profitable partnership. The crab gets his tail protected; he is largely hidden from his enemies; he is hidden, too, from the things that he desires to attack. The anemone is carried about, and is kept in constant touch with an ample supply of food. Thus we have a life partnership between the simple-looking plant-animal and a desperate warrior who is always battling.

The study of anemones is a most interesting one, and one which many can pursue, for they abound wherever rocks strew our shores. Think of them not as plants, but as animals, of which the larger will swallow a shell the size of a saucer, and then divide into two living animals rather than lose the booty it has managed to secure.

The anemone is not the only sea-animal with which the crab goes into partnership. There is a certain sponge in which he makes his home. We know that sponges are not vegetables, but animals. They admit the sea-water through the canals in their bodies. From this they extract tiny forms of life for their food, and at the same time take for their breathing the oxygen which the water contains. That is the way fishes breathe. They have gills, over and through which the sea-water washes. These gills take the oxygen from the water and pass it into the blood-vessels, so that the fishes may breathe as we breathe. The method is, of course, very dif-

ferent, but the purpose and result are the same. That is the way in which the sponge, no matter what its name or size, breathes and feeds and grows.

In some of the channels running through the sponge may be found the hermit-crab. Higher up in the same channel may be discovered a little shell, and also a little worm. In this collection we have the history of four forms of life. First of all, the hermit-crab pops his naked tail into the empty shell left by a growing whelk. Then comes a young sponge, sent forth on its life journey by its parent. It settles upon the whelk-shell in which the crab has sheathed his tail. There the sponge grows and grows until it quite covers the shell, leaving open a channel by which the crab can enter and leave. As the sponge and the crab grow bigger they take into partnership a little worm, which is admitted into the interior of the sponge so that it may devour any refuse which collects in the home of the crab. Even such humble things as crabs and sponges have to guard against unclean homes. That is why we find the interior of the sponge occupied by a shell, a worm, and a crab.

THE BRILLIANTLY COLORED FISHES OF CORAL REGIONS

WHERE corals abound, fishes of the most brilliant color are always to be seen. The fishes protect themselves by becoming colored like their surroundings, just as the animals do. But swimming with them are marvels of colored jelly, apparently. They are the jellyfishes. We all may see jellyfishes at the seaside when the tide goes out. Better still, on a favorable day, we may see hundreds of them floating on the sea as we travel by steamer. They look like great white or transparent leaves, with a little dash of red in the center as though they had been darned with colored wool. The jellyfish of brilliant color belong to the warm seas of the tropics. But the nature of all jellyfishes is much the same.

Those of the tropics give off a brilliant silvery light at night, which helps to make the sea like a gleaming mirror of liquid metal. If we catch one and lay it on a piece of blotting-paper for examination, we have to be very quick, for the jellyfish is composed largely of water, and it simply dries up before our eyes. They are not nice things to handle; they can sting very badly, as all sea-bathers know. The scientific name of the jellyfishes and their kin is taken from the Greek word which means nettle, and sea-nettles is another name for the jellyfishes that sting.

By far the most alarming of the sea-nettles is

the Portuguese man-of-war, or physalis. This looks like an inflated bladder, six inches long. Beneath it stream a number of organs, important to the animal in gathering and distributing food. The tentacles that we most wish to avoid are those which carry the stings. These are intended to numb the prey of the physalis, but woe to the man who comes in contact with them. They flow out some feet from the body of the animal, and are heavily charged with stings and a poisonous fluid. The merest touch from them will raise a white swelling on the hand, and for long afterward the hand and arm experience an aching pain, which gradually extends to the muscles of the chest, causing some trouble in breathing. Even when they have been removed from the body of the physalis the stinging cables retain their power to injure, and from them issues a fluid which, after lying upon cloth for some days, still has power to sting.

The sea-anemones, the corals, the jellyfishes, and many other plant-like sea-animals, all belong to the same family. We have another interesting family including starfishes, sea-urchins, sand-stars, brittle-stars, feather-stars, and so forth.

THE STARFISH, THAT WALKS ALONG THE BOTTOM OF THE SEA

We have all seen many starfishes at the seaside. There is not a simpler, more innocent-looking thing to be found by the sea than the starfish, particularly that commonest of all, the crossfish, as we call the five-fingered one. Yet it is a really wonderful creature. Its organs are in the center of its body, and the fingers, as the rays are called, branch out from that center. Now, the fingers are really legs, for there are tubular feet underneath them by means of which they walk as comfortably along the sea-bottom as we walk along the beach.

The starfish has a terrible appetite, and oysters, mussels, scallops, and other shell-fish are its food. With its long and strong arms or fingers it seizes its prey, and, no matter how powerful the shell may be, by persistent pressure the starfish manages to force it open, and then eats the fleshy interior. Fishermen hate the starfishes, and when they catch them they tear them in two and fling them into the sea. That is not only cruel, but also very stupid. Though you tear a starfish in halves, the animal can recover. Each of the halves heals and grows new fingers, and instead of a dead starfish in two halves, you soon have *two* starfishes, fully equipped for hunting and very much alive.

THE SEA-CUCUMBER THAT THE CHINESE LIKE

WHAT we call the sea-cucumber is also an animal. Its other names are the sea-pudding, the sea-slug, and the trepang. It has the same sort of feet that the starfish possesses—suckers which protrude from tubes—and can get along over places which seem quite impossible.

The common name of the sea-cucumber suggests the idea which its appearance presented to those who bestowed the title upon it. The Chinese consider it a great delicacy for the table. There are many kinds of sea-cucumber, and the rarest bring quite high prices. It does not seem nice to eat sea-slug, and we are content to leave it to the Chinese. But perhaps they consider the tastes of those who delight in turtle soup quite as strange as we take their taste to be.

We have glanced briefly at some of the lowest forms of life in the sea. It is quite as wonderful as life among the higher animals. We do not expect much of animals that seem to be no more highly gifted with life than plants; but, as we have seen, there is a mystery and fascination about these lowly creatures sufficient to make even the wisest men marvel at their habits.

WONDERFUL ANIMALS IN THE SEA

THE age of giant animals has not quite passed away. There are giants still in the sea, so big that the biggest animals on land would seem small beside them. They could not get food enough on land, so they have changed from land animals into sea animals. There, in the vast deep, great whales live their lives amid friends and terrible enemies; and whales are not the only animals which left the land for the ocean. Seals of many sorts pass the greater part of their lives in the sea, but they come to land for a certain time each year. Then they go back, having first taught their babies, which are always born on land, how to swim and hunt for their food in the deep. In reading about Nature's great family of animals, perhaps we may feel a little vexed to think that this is the day of small things—the day of smaller lions, and tigers, and reptiles; of smaller birds and other creatures than once lived upon the earth. But there still live creatures as big as any that the world has known. Not even in the old days, when many creatures were monsters in size, was there a bigger animal than the whale which swims the seas to-day.

"But whales are fishes," you will say. Nearly everybody thinks that. They think that whales and dolphins, and porpoises and manatees and

dugongs, are fishes, like the shark and the fishes that we eat. Scientists also thought so many years ago. But these creatures which we have been mentioning are really animals. They are mammals, which, as you know, are creatures that feed their young on milk. The whale is a mammal, like a fox or an elephant.

As whales live in the sea, you would not think that they could be drowned; but they can. They, like ourselves, have to breathe the air of the atmosphere to live. To do so they must come to the surface of the water. You know the cry of the whalers. "There she blows," they cry when they see a monster rise to the surface and spout streams of water and vapor into the air. When the whale comes up to spout, it means that he has been down under water as long as he can, and has been driven to the surface to breathe out the air which has been used up in his body, and to take in a fresh supply.

Now, as he must remain below at great depths for a long time, the whale has a specially developed system of vessels in which it stores up blood purified by the air which it has taken in. This reserve of oxygen it uses up slowly while it is below the surface; and by this wonderful provision it can remain in the depths for a very long time.

For a long time clever men were puzzled to know why the whale has a monstrous flat tail. Most fishes have tails which are upright. The whale's tail is flat. The whale would not be perfect without a flat tail. As it is so huge an animal, much strength is required to drive it through the waters, and still more to raise it from a great depth to the top of the water. Fishes have gills with which they breathe the oxygen actually in the water. Whales must breathe in the open air itself. The fishes are quite well served by their upright tails, which steer them through the waters when they are swimming horizontally or flat in the water. But the whale wants suddenly to bound from the depths of the ocean to the top of the waves. His immense flat tail, which measures about 18 feet across, is the lever which lifts him. With two or three movements of this tail he drives himself to the top of the sea, to breathe and blow and spout to his heart's content. This is why the shape of the whale is different from that of most fishes.

A WHALE THAT WAS BURIED FOR THOUSANDS OF YEARS

ONCE upon a time, ages and ages ago, whales were probably like frogs, in the sense that they could live either on land or in water. They were,

most likely, great hairy animals with four legs. Some of them were armored like the crocodile. The remains of whales of other ages are so numerous, buried in the earth in parts of our country, that farmers occasionally find their bones. Many years ago the remains of a whale were found embedded in a cliff on the sea-front at Brighton, England. A storm had washed away part of the cliff, and fishermen found a bone 9 feet long sticking out of the cliff. When the remains were examined they were found to be those of a whale over 70 feet long, which had died thousands of years ago.

Not all whales have teeth—the whalebone-whales have none. But the baby whales all have teeth, showing that long ago all whales had these weapons. The main difference between various kinds of whales to-day is in the matter of teeth. That difference is important, because it decides what food the whale shall eat. One sort of toothed whale, the grampus, has such good teeth that it has become a cannibal. Not content with cuttlefish, huge jellyfish, and seals, it eats other whales. The toothed whales include the sperm-whale, the bottlenose, and lesser sorts. The whale without teeth, called the baleen-whale—that is, the whale which furnishes whalebone—is the most valuable of all whales. The whalebone is worth over \$10,000 a ton.

A WHALE'S MOUTH IN WHICH A BOAT COULD FLOAT

LET us try to picture a baleen-whale. An average size for such a whale is from 60 to 70 feet in length, and from 30 to 40 feet round the thickest part. The head is about 20 to 25 feet long. On top of the head are the two nostrils, placed there so that the whale can breathe the moment it comes to the surface. The nostrils can be closed by valves, which keep the water from entering the nose and reaching the lungs. On its back the whale is of a dark color, so that, with the light shining down through the water, the back of the whale looks like the water itself. Underneath the whale is light in color.

The mouth of the whale is the biggest in the world. When the jaws open it looks as if the huge head had split in two. The length of the jaw is about 16 feet; it is 7 feet across, and, when open, the space between the lower jaw and the roof of the mouth is a good 12 feet. Thus a ship's boat could go comfortably into the open mouth of a whale. But this great cavern is more like a jungle than a cave. This whale has not a tooth in its head. The lower jaws are smooth

and polished, but from the upper jaw hangs the famous baleen, or whalebone.

THE WHALEBONE IS THE WHALE'S GREAT FISHING-NET

THE whalebone which you buy is not cut from the body of the whale; it is the network of plates hanging down from the roof of the mouth. A cow has hard, broad ridges on the roof of her mouth. So has the whale, only here they are greatly enlarged. The plates are thick and solid where they grow out of the roof of the mouth, but they taper away, and at the ends appear like hair. That is really what they are—plates of hair hardened into a sort of horn, fringed at the end. Of these plates there are from 300 to 400 on each side of the upper jaw, and their weight, in a big whale, is a ton and a half.

What is the purpose of this great mass of whalebone in the monster's mouth? The mouth of the baleen-whale is his vast fishing-net. Although he is the biggest creature in the sea, this whale eats the smallest creatures, chiefly little jellyfish. He has to catch these in shoals to satisfy his appetite, otherwise he would starve. So he swims into a great shoal of the things which form his food. How does he find them? He can see, and probably he can smell. When he reaches a shoal of eatable things, he charges right through it, with his mighty mouth open. The tiny jellyfish are taken in crowds into his mouth. The great jaws close like a drawbridge. The whalebone folds back toward the throat. In the forest of horn and hair are the fish and other things which he has caught. As the whalebone sinks back, these drop down to the whale's tongue, and the water squirts out at the sides of the mouth. Then the whale swallows his "catch."

TINY FOOD FOR THE LARGEST MOUTH IN THE WORLD

THE reason for all this is that the whale must have tiny things to eat, because its throat is so small. Big men could stand upright in the mouth of the whale, but its throat is so small that it could hardly admit a man's fist; while the tube down which the food passes to the stomach is only about as thick as an ordinary walking-stick. The throat is fitted with muscles which cause it to close up like a spring trap after the food has been admitted. So much for the mouth.

The body itself is peculiar and wonderful. Over all is the thick oily skin. It is oily so that the friction of the waves may be lessened. Un-

derneath there is a second skin, which gives the whale its color. Still lower there is a third covering, the blubber-oil and solid fat. It forms a great blanket round the whale, in places 2 feet thick. This blubber weighs quite 30 tons, which is as much as the weight of nearly 500 men.

WHY IT IS THAT THE WHALE IS THE FINEST OF ALL DIVERS

THE oil and blubber serve a double purpose. In the first place, they keep the whale warm—for the blood of the whale, remember, is warm like ours. Next, they act as a protection against the force of the waves. Our best men divers cannot go down more than a few score feet, and the finest ships made for descending into the depths of the sea go only a comparatively little way, because the pressure of the water is so enormous. But a whale, after having taken a breath, will plunge a mile deep, and at that depth the weight which it has to bear upon its whole body is some 211,200 tons, or over 137 tons on every square foot of its body. Nothing else can bear such a pressure. Some fish which live low down in the water burst when brought to the surface, because the pressure necessary to keep them whole is removed. Other fish, if forced deep down into the water, would be crushed by the weight of water which they would there have to support. But here we see that the whale, thanks largely to its blanket of springy blubber, can bear the pressure of the deep sea, and then come to the top and not be hurt when the pressure is removed.

Men hunt the baleen-whale for its whalebone and blubber. The blubber makes oil. The whalebone is put to many uses. The whale swims from the frozen seas of the north to the warm seas of the south; so the whalebone, when removed from its mouth, will stand all sorts of climates. The best whale of this type is the right whale, called also the Greenland whale, or the bowhead. One of these has been known to yield $1\frac{3}{4}$ tons of whalebone, as well as 275 huge barrels of oil.

Now we come to the toothed whales. Of these the largest is the cachalot. This has no teeth in the upper jaw, but those in the lower jaw number from forty to fifty, and weigh from two to four pounds each. The jaws are enormous, for the head is nearly a third of the whole length of the body, which, in a large one, measures from 70 to 80 feet. These figures describe the male whales, for the females are smaller. The cachalot is called the sperm-whale. The reason for this is the substance stored in a great chamber of the head. This chamber lies behind the nostrils, from which it is divided by a thick wall of bone, semi-

circular in shape and several feet high. When a sperm-whale is caught the head is cut open, and men lower buckets into the opening and take out the oil in it. This oil, when refined, gives spermaceti, from which the finest candles and many ointments are made. From one cachalot, which measured only 64 feet, there were obtained 24 barrels of spermaceti and nearly 100 barrels of oil, from which the spermaceti had been refined. Another strange product of the sperm-whale is ambergris. It is a speckled gray, fatty substance, into which the whale changes part of its food, as the civet changes its food into a musky pomade. Ambergris used to be found floating on the sea, and men thought it was a kind of amber, and called it ambergris for that reason. But now we know that it is produced by the sperm-whale, in whose body as much as 50 pounds at a time have been discovered. Formerly ambergris was used for medicine, but now it is used only for scent. Even when it is plentiful, manufacturers pay ten dollars an ounce for ambergris, but when it is scarce they are glad to get it at thirty dollars an ounce. A whale with 50 pounds of ambergris would be worth from eight thousand to twenty-four thousand dollars for this alone, to say nothing of the value of its oil and spermaceti.

THE TERRIBLE SEA-FIGHTS OF THE GREAT TOOTHED WHALES

THE value of the whales for whalebone and ambergris, oil and spermaceti, causes them to be cruelly hunted by men, and in some seas where whales used to be plentiful hardly any are now to be found. Luckily, the seas are wide and deep, and there will always be some place to which the whales may go where men cannot find them. But they have other enemies as well as men. The sperm-whales fight fiercely among themselves. The males battle with other males, and kill each other. Great toothed whales have been found dead with their mighty jaws fast locked together. They had fought to the death, and in their closing struggles had got their jaws so tightly locked that they could not be separated.

THE GREEDIEST BEAST THAT LIVES IN THE WATERS

THE cannibal whale is the grampus, or "killer," as sailors call it. This is a toothed whale of a different type. It has teeth in both jaws, and is the greediest beast in the waters. One grampus has been known to swallow several seals one after another. Although the grampus attains a length of over 20 feet, it would be no match for

a sperm-whale in single combat, so several grampuses hunt together, like wolves. By weight of numbers, by their repeated attacks with their powerful jaws, they are able to tire out the biggest whale, and kill and eat it. They sometimes have powerful allies in the sawfish and the swordfish.

Though the names of these two creatures are similar, the fishes themselves are very different. The swordfish has a great spear growing out from its snout. The sawfish has, in the same place, a blade of the hardest bone, from both sides of which grow out horrid saw-like teeth. The swordfish darts with great violence upon its enemy, and stabs with its sword. The sawfish makes the same sort of rush, but it does not stab and draw out its weapon as the swordfish does. Instead, when it has thrust its cruel weapon into the soft part of its victim's body, it actually saws with it, tearing open a great wound, from which even the whale, lord of the waters, must die. Sometimes the swordfish and the sawfish join with grampuses in attacks upon the whale. The swordfish reaches a length of 20 feet; the sawfish grows to over 12 feet; so the poor whale, with such savage and powerful foes, has not much chance of life.

THE WONDERFUL STRENGTH A FISH CAN PUT INTO ITS SWORD

THE strength of the swordfish is almost incredible, but here are two instances to show what it can do. One swordfish, mistaking a ship for a whale, rushed at it, and drove its weapon through the sheet of copper with which the hull of the vessel was covered, through a plank of oak $2\frac{1}{2}$ inches thick, through a beam $7\frac{1}{2}$ inches thick, and then through another plank of oak 2 inches thick. Even then it might not have stopped, but at this point the sword broke off.

Another swordfish, attacking a whaling-vessel, drove its spear through the copper and then through $17\frac{1}{2}$ inches of the hardest oak, and finally through the timber of a barrel of oil. There the weapon remained fixed so tightly that not a drop of oil escaped from the barrel. These are the natural enemies that the poor whale has to face. He himself never attacks other large creatures, being the most harmless animal in the sea, unless he is enraged by enemies. In that case he is a terrible foe. With one blow of his awful tail he can shatter the side of a boat. He can send a small boat flying out of the water into the air, or, with a single snap of his jaws, can bite it to fragments.

It is a blessing that the angry whale does not

live on land. The paddles with which he swims are his hands. He used to have hands exactly like ours, only larger—with four fingers and a thumb. The fingers and thumb are still there, but now they are covered over with skin and flesh to form a paddle or fin. Deep down in his flesh we also find remnants of the bones which, ages ago, formed his hind legs and feet. His ancestors must have lived on land.

THE SEA-UNICORN, OF THE WHALE FAMILY—THE PORPOISE

PORPOISES and dolphins do not seem, at first sight, to resemble whales, but they are members of the toothed-whale family. The most curious of the family is the narwhal, also called the sea-unicorn, because it has a long horn of ivory growing out from its snout. This is not like the spear of the swordfish. When a baby the narwhal has two little tusks in the upper jaw. These never grow any bigger in the female, but in the male the left tusk grows to a great size. The right remains small, though it increases in hardness. The left becomes a rod of spiral ivory, from 8 to 10 feet in length. With this weapon the narwhal can do great damage to fishes and to boats. But it has no ordinary teeth, so it has to content itself with soft food like the cuttlefish.

A close relation to the narwhal is the white whale, or beluga, from the skin of which much of the so-called "porpoise-leather" is made. It is a valuable animal to the Eskimos, who eat its flesh and use its blubber for oil, use its skin for various purposes, and finally feed their dogs upon what they themselves cannot eat.

One of the commonest of sea-animals is the porpoise, a handsome, graceful animal, of which the largest are about 5 feet in length. It has more than 100 teeth, and its jaws lock together perfectly so that once it seizes a salmon, a herring, or a mackerel, there is little chance of the victim escaping. The porpoise has a tiny ear, and there remains a spot near it which shows that once it had an outer ear, like the eared seal. An interesting discovery about the porpoise is that it has on its back fin a number of horny knobs. These are the last remnants of the bony armor in which sea-monsters were clothed after they had ceased to wear a covering of hair. Porpoises are magnificent swimmers, and no fish can escape them.

THE LIVELIEST ANIMAL IN THE SEA, WITH OVER 100 TEETH

THE dolphins are a little longer than the porpoises. They are different, too, about the head. The head of the porpoise is short. The dolphin

has a beak like that of a great bird, but in it are more teeth than any other animal has—more than 120. Its food is like that of the porpoise, but it likes shell-fish as well as fast-swimming fish.

The dolphin is the liveliest animal in the sea. It assembles in herds of twenty or more, and leaps and tumbles and gambols in the waves as merrily as squirrels in the trees. Dolphins will follow ships for hundreds of miles, and there has never been a ship which the swift dolphin could not outpace. The porpoise has a voice, and cries loudly if in distress. So has the dolphin, but it uses its voice for calling to its companions. It is like the distant lowing of a cow.

It is not the lowing of dolphins which makes men believe that they hear and see mermaids at sea, neither is it the sight of dolphins which deceives them. The so-called mermaids are two sea-animals, the manatee and the dugong. Together they form one family, which are called *Sirenia*, a name given them from their fancied resemblance, in the face, to mermaids or sirens. To an ordinary person they look like a kind of porpoise. But they do not eat fish; they live on seaweed and water-plants. The manatee always lives in the shallow sea, but the dugong goes up rivers and eats the plants which grow in their beds.

Both these animals have round, black heads. When feeding their young they hold them in their arms, or flippers, so that the heads of the mother and baby are above the water. Sailors have seen them, and thought that they were mermaids. For thousands of years it was believed that there were mermaids and mermen, human creatures with the tails of fishes. When you see the manatee and the dugong you will wonder how people could have mistaken them for human beings.

HOW THE SEALS SUFFER THAT WE MAY WEAR BEAUTIFUL FUR

WHEN you see a sealskin jacket perhaps you never think of the thousands of miles which that lovely fur has traveled in the depths of the ocean. If people realized what cruelty is practised in getting the fur, they would not wear it. The seal is one of the most wonderful creatures in the sea, and used at one time to approach boats and villages by the sea, as if it wished to be in the company of men. But because some kinds of seal have fur which men and women wear, and because others yield blubber for oil, and skins which make leather, men have hunted it so savagely and persistently, in spite of laws

for its preservation, that the number of seals is rapidly being so reduced that in a short time there will be scarcely any left in a wild state.

The seal is an animal which lives the greater part of its life in the sea, but every now and then it goes on land, or rests upon floating ice, and it is then that men kill it. Each spring the old seals go to certain islands to rear their young. The old males go first, and the females and younger males follow. The elders fight savagely and long until all the families are collected.

When the babies are born they have to be taught to swim, for the young seal does not take naturally to the water. At first it seems to dislike it, but the wise mother gets it down to the waves, shows it how to swim, and makes it at home in its new element.

With the old seals have come seals born the year before or the year before that. Men are on the lookout for these. They drive them into the interior of the island, away from the others, and there knock them on the head with clubs, and skin them before they are really dead. These are not the only seals killed. The mothers and fathers of the baby seals, and even the little ones, are slain. It is a cruel and horrible trade, that of the seal-hunter, and makes people who know ashamed that such things should happen. Of course, some seal-hunting would have to be done, for if seals were too numerous they would destroy too many fishes in the waters where men fish for human food. But where the baby seals are reared, and away from men's fishing-grounds, there is plenty of room as well as plenty of food for seals.

There are many kinds of seals. One, called the hooded seal, has a sac over its nose, which, when the seal is excited, it can inflate. Another, called the harp-seal, has a figure like a harp marked upon its sides. The leopard-seal is beautifully marked like a leopard. The common seal does not give the precious fur, but it has valuable oil, and its skin makes leather.

THE HUGE ELEPHANT THAT PARADES THE WATERS

A RELATIVE of the hooded seal is the sea-elephant. This is a giant, and doubly deserves its name. It measures, when fully grown, from 20 to 30 feet in length, and from 15 to 18 feet round. Thus it is actually bigger than our land-elephant. It has a long snout like the trunk of an elephant. When on land it walks awkwardly on its four feet, or flippers. The common seal has its hind legs turned backward, and uses them only for swimming. It does not walk, but

has to jerk itself along by a series of shuffles, and for this purpose it has very strong muscles in its body.

The seal which bears the fur is called the sea-bear. It is nearly allied to the sea-lion, but the sea-lion has only long hair, not fur. The sea-bear has long hair, but underneath is the beautiful fur which keeps it warm. All seals are fine swimmers. Ships follow and hunt them in certain parts of the year, sending off boats from which men shoot or spear them. But when the time comes for the seals to go to the land, they increase their pace, and swim with such swiftness that no ship can keep up with them. After that, other men follow them to the land.

The sea-lions have their hind legs turned forward, so that they can get about fairly well on land. They can climb, too.

Sometimes they are found upon icebergs, high up on the ice, and sailors wonder how they can have jumped so high. They have great leaping power. What a sea-lion can do was once shown at the London Zoo. On the day of its arrival it was put in a pond, around which was a railing 3 feet high.

In the morning it was found that the sea-lion had left his pond, climbed over the railing into another pond, out over the railing of that pond, and then into the pond where the swans were. Whether he would have killed the swans or not, we cannot say—he was not hungry at the time. But seals will eat birds. Sometimes they snap up sea-gulls, and they often eat penguins. In the stomach of seals are often found a number of stones, and some naturalists believe that those stones have first been swallowed by the penguins which the seals have eaten.

SEALS RUSH TO THE SHORE ALTHOUGH THEY FIND NO FOOD THERE

If you have ever seen seals or sea-lions you know what a noise they make when feeding-time is near. They have a sort of hoarse bark when full-grown; the babies "baa" like lambs. No other animal has a better brain than the seal. They love music. The sound of music in a seaside village will, it is said, often draw them to the shore.

The seals are like the camels and the whales—they can close their nostrils tightly, and keep out anything which they wish to exclude. This is necessary for them when in the water. They can remain below the surface without breathing

for a long time. Another curious thing about them is that, though they get enormously fat when in the water and feeding regularly, they can go without food for three months at a time. For a quarter of a year they remain on land while their families are growing up, and in all that time they never go to the sea for food. They fast for three months without a break, and go back to the sea as lean as skeletons.

THE WALRUS, A SEA-GIANT WITH TUSKS OF PURE IVORY

THE walrus is included among the seals, though it really is not a seal. Its body is in most respects like the body of an elephant-seal. It grows to a huge size, being from 12 to 15 feet long, and very heavy. It can walk, in an awkward, waddling way, on land. Its most remarkable feature is a pair of enormous tusks which grow downward from its upper jaws, like the tusks of the extinct saber-toothed tiger. These are of the purest ivory, and measure fully 24 inches from the point at which they emerge from the gum. Although he is such a monster, the walrus is one of the least destructive of all the sea animals. Its mighty tusks serve to grub up shell-fish, shrimps, and other little things which live at the bottom of the sea where he makes his home. The shell-fish he cracks with his teeth; he puts out the broken shell, and with his tongue draws out that part which he wishes to eat. The tusks are said to help him to climb on the ice, and on rocky islands to which the walrus retires to rest.

THE GREAT LOVE OF THE WALRUS FOR ITS LITTLE ONES

If he can, he will always take to the sea when attacked; but should he have to fight, he can inflict frightful injuries with his tusks.

He is hunted for his blubber and skin as well as for his bristles. The walrus and all the seals have strong bristles about their mouths. These may act as feelers, as the cat's whiskers do; but it is supposed that they serve the same purpose as the whalebone in dredging and screening the shell-fish which the creatures seek for food. Seals and walruses are devoted to their little ones. The male walruses will give their lives for their babies. Hunters kill the mothers and babies first, because they know that the male walrus will stay and fight to the last.

WHAT I FOUND ON A PIECE OF SEAWEED

BY EDMUND WILSON

You all remember having read in your histories about the first voyage of Columbus, and have not forgotten that when the three little vessels were only half-way across the broad expanse of the Atlantic, they sailed through great masses of floating seaweed. The sailors thought these seaweeds must have been torn by the waves from some neighboring coast, and therefore believed their voyage was nearly ended. But, as they sailed onward, anxiously straining their eyes to catch the first glimpse of land, all the seaweed was left far behind; and it was not until many long days had passed that the distant line where the sky and water met was broken by the shore of the New World.

Now, the naturalists who study seaweeds have given the name *Sargassum* to the kind that misled Columbus. They have found that the *Sargassum* (which is also called gulfweed) probably does not need to grow fast to the shore like the common seaweeds you have seen at the seaside in summer, but has little round air-bladders, or floats, which buoy it up so that it seems able to grow and flourish at the surface of the sea, even many hundreds of miles from land. Vessels in the very middle of the Atlantic Ocean often sail for days through the floating meadows formed by this curious plant, and sometimes even powerful ships have hard work to push their way through.

One calm September day, I was cruising about in a little steamboat, off the southern coast of the United States. The sky was cloudless, and the bright sunlight streaming down into the clear water enabled us to see far below the surface.

We could see great jellyfishes lazily flapping along; and now and then a shark would dart by, making the small fishes scatter in every direction as he passed. Presently we saw masses of this gulfweed floating about us, and seizing a long-handled net, I fished up a piece as we steamed along.

I suppose many people would have thrown it away as a useless piece of weed; but we knew better than that; for, when we came to examine it carefully, we found that the *Sargassum* was the home of a number of strange creatures which were so curious and interesting that I must tell you something of them. Here is a picture of the *Sargassum* just as it looked after being fished up, and put into a big glass jar full of pure sea-water.

The round knobs on the stem are the air-

bladders, which keep the plant afloat so that it rises and falls with the waves, and drifts along on the tides and currents. Perhaps this piece had drifted hundreds of miles, for the Gulf Stream,



THE SARGASSUM.

which flows northward like a mighty river from Florida and the West Indies, may have borne it onward for many weeks.

Our seaweed may therefore have been a great traveler, and may have had some strange adventures on its way. We may be sure it has weathered some great storms, and has been well tossed and shaken about by the big waves. The white gulls have wheeled about in the air above it, or even brushed it with their wings as they paddled along beside it. Perhaps some savage

shark has given it a slap with his huge tail, as he darted by in pursuit of his prey.

Could the *Sargassum* speak, it might tell us whether there really is a sea-serpent or not! But it tells no tales; it floats there in the jar very quietly and unconcernedly, and so we must see what we can find out from it for ourselves. If you look closely at the picture, you will see some very odd things indeed. After we had fished up the *Sargassum*, one of my friends was watching it in the jar. Suddenly she exclaimed, "Why, the seaweed is *alive*! It is moving its leaves."

We could hardly believe our eyes, and yet some of the leaves certainly were waving to and fro, though the water in the jar was perfectly quiet. What could it mean? All at once we became aware that there, crawling on the plant, were two large sea-slugs, which had entirely escaped our notice. And the curious part of it is that their bodies were of exactly the same color as the stem of the *Sargassum*; and that each one had growing from its body three pairs of things shaped and colored precisely like the leaves of seaweed, but really parts of the animal. These were the "moving leaves" which had excited our wonder. To make the illusion more perfect, the leaf-shaped appendages were covered with little, branching, tufted outgrowths, closely resembling something growing on the real leaves of the plant, about which I shall tell you presently.

Here is a picture of one of these curious animals when separated from the seaweed. It is



A SEA-SLUG.

really very similar to a snail without any shell, or like one of the slugs you may have seen on damp, decaying wood, or upon apples lying beneath the trees in the

garden—only, the imitation leaves disguise its real character. The pointed end is the tail, and the other end is the head. The front pair of false leaves are short and blunt, and look very much like some of the dead or imperfect leaves of the plant. The conical structures on the front sides of them are feelers, or tentacles, of which the sea-slug has great need, for it has no eyes and must guide itself in another way.

The two sea-slugs are easily seen in the illustration, because they are not colored. But I can hardly tell you how perfectly they resembled the seaweed when alive. Their bodies were a beautiful, reddish-brown color, exactly like the stem of

the *Sargassum*, speckled with pure white and dark brown, imitating the spots and patches on the latter. The imitation leaves were olive-green, precisely like the real ones, with a few darker blotches to imitate the stains and decayed spots. Altogether, you can hardly help fancying that the sea-slug has dressed himself up in the seaweed's clothes and is playing a sort of masquerade.



A LITTLE CRAB FOUND ON THE SARGASSUM.

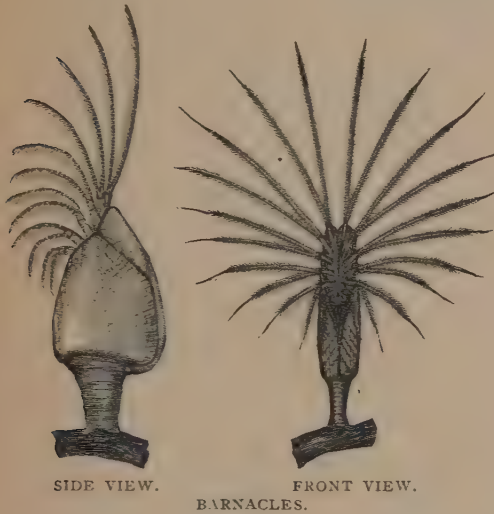
But the sea-slug has been disguised as a plant for a good reason. For the sea is full of hungry fishes, always roving about on the lookout for just such a titbit as a sea-slug. The sea-slug therefore has been colored and shaped like the seaweed it lives on, in order that, when some sharp-eyed fish comes swimming along, he may never dream so tempting a morsel to be near. I suppose he looks at it and turns up his nose, saying to himself, "Pooh! that's nothing but an old seaweed!" and off he goes, while our sea-slug no doubt laughs in its sleeve and says, "Seaweed, indeed!"

This wonderful resemblance is an example of what naturalists call "protective resemblance," which in this case is so perfect as to merit the name of "mimicry." Because, you see, the animal *mimics* the plant, and is thus *protected* from its enemies.

Now, let us see what else we can find on the *Sargassum*. In the first place, you see a queer little crab on one of the leaves. He is such a little fellow that we must magnify him a great deal to see just what he is like.

Here he is as he looked under my magnifying-glass. He has two huge black eyes, with which he keeps a good lookout, and at the least alarm he whisks around to the other side of the leaf in a twinkling, just as a woodpecker dodges behind a tree. When alive he was beautifully marked with red and black, and so transparent that you could look into his body and see that his heart was beating and his stomach digesting his last meal.

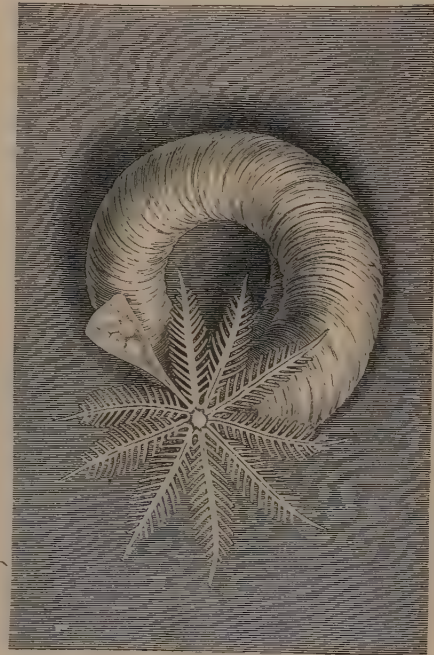
A little higher up, two barnacles are grown fast to the stem, with their arms spread out in the water. You can see them better in the two separate pictures, one of which shows the barnacle from the side and the other from in front. What does he do with the long, hairy arms? If we watch him for a few moments, we see the arms suddenly pulled entirely in—they shut up just as you close your hand by folding your fingers together. In another instant the arms are put forth again, and make a grasping or clutch-



ing movement in the water, after which they are again withdrawn. So the barnacle goes on, continually grasping in the water, and, of course, you have guessed what he is doing. Yes, he is fishing—he is trying to make a meal of the microscopic creatures which are swimming about in the water. You see, the barnacle is grown fast at one end to the seaweed, so that he cannot swim about in pursuit of his tiny prey. He must wait for the unlucky little fellows to come within his reach. And as he is stone-blind, having no eyes, he cannot keep watch, so as to throw his net at just the right moment; he has to keep grasping away at haphazard, and be content if he makes a catch only now and then. But woe betide the little shrimp or worm that is unwary enough to come within reach! The long arms instantly close on it; it is dragged down into the terrible jaws, torn to pieces, and eaten. And then the lucky fisherman begins to throw his deadly net again.

Now look carefully at the picture, and you will see two or three little star-shaped objects attached to some of the leaves. If we magnify one of these, here is what we see. There is a little

coiled tube, as hard as stone, within which lives a little worm, which the naturalists call *Spirorbis*. When he puts out his head he spreads out in the water a star-shaped circlet of feathery arms, which looks very much like a delicate flower. A very dangerous flower it is, though, this pretty star of feathers, for it is another fishing-net like that of the barnacle—only, the feathers are held quite still, and move only when the animal is alarmed or when they close upon some unlucky little creature which ventures too near. If the *Spirorbis* is alarmed, he instantly pulls in his head with its fishing-net, and when he goes into the tube he securely corks up the opening with a kind of stopper or plug, which he pulls in after him. You can see the stopper in the picture, occupying a position opposite to one of the arms.



THE SPIRORBIS.

A curious fact is, that the stopper is hollow, and in this cavity the mother *Spirorbis* carries her eggs until the young ones are hatched. The eggs are shown in the figure as little round balls.

Are you getting tired of the seaweed? Well, I will tell you of just one more thing, and then we will leave it. You will see little dark patches on some of the leaves. In the real seaweed these patches look like small tufts of moss. But these moss-like growths are really colonies of microscopic animals, which have been called *Bryozoa*, the zoological name for "moss-animals." Under

the microscope we see a most curious sight, which I have tried to show you in this drawing. Each one of the tiny specks has become a flower-like creature, looking not very unlike a dandelion or field-daisy. But you would think them very wide-awake flowers, for they are all swaying back and forth, moving the arms about in the water, and every now and then one of them disappears in a twinkling. In its place is left an oval opening; and, if you watch carefully, the flower gradually and cautiously comes forth from the opening again, and spreads out in the water its graceful crown of arms.

You see, each moss-animal has a little stony house, or cell, in which it lives, and from the mouth of which it can spread out a flower-like fishing-net, not so very unlike that of the *Spirorbis*. All these cells are so joined together, that they form a kind of coral, somewhat like that of real coral - animals which make the vast coral-reefs or coral-islands. The fishing-net is interesting in its structure. Every slender arm is covered with little vibrating hairs or paddles (too small to see in the drawing), which are constantly waving to and fro when the arms are spread out. All the paddles move together, and in such a way that a little whirlpool is made in the water around each animal, and the bottom of the whirlpool leads right into the creature's mouth, which is in the middle of the flower.



"MOSS-ANIMALS."

You have read the stories (which you must not be too ready to believe, though) of the great

Maelstrom, or whirlpool, off the Norway coast, into which boats and men are said to be drawn, and after circling round and round, faster and faster, and ever approaching the middle, are at length sucked in and swallowed up by the mighty waves. Well, the whirlpool about each moss-animal is equally terrible, in its way, to the little creatures swimming in the water; for if they once come within reach there is no escape—they are sucked in and swallowed *alive* before you could say, "Jack Robinson." And here I must tell you something curious. The bodies of all the moss-animals are joined together, so that whatever each one eats benefits all the rest, and there can be no quarreling among them over their dinners.

The little feathery tufts on the lower leaves are animals, too, and are called hydroids; and, under the microscope, they much resemble the moss-animals. Like them they have separate heads and mouths, but their bodies, and even their stomachs, are all joined together.



HYDROIDS.

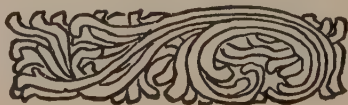
Besides the sea-slugs, crabs, barnacles, spirorbes, bryozoa, and hydroids, many other little creatures grew fast to the seaweed. But I must not try to tell you about these, for very likely you have had quite enough seaweed for one time.

It is a curious thought that there are countless thousands of these seaweeds in mid-ocean, drifting about at the surface of the sea, every one the home of a little society more or less like the one I have told you about.

A poet once said:

"There's never a leaf nor a blade too mean
To be some happy creature's palace."

And no doubt our little crabs and barnacles, with their queer traveling companions, are quite happy and well content in their floating home, though a thousand miles from land and buffeted about by winds and waves.





ICEBERGS

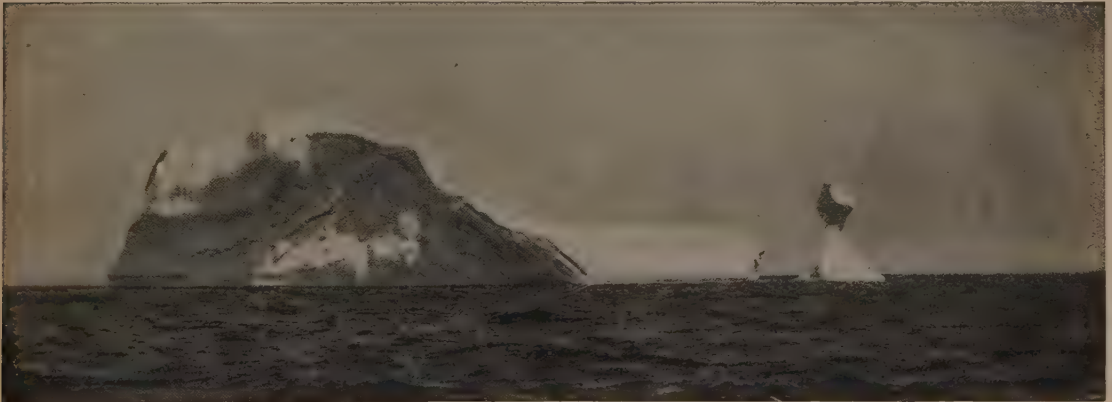
BY DAY ALLEN WILLEY

"FROM Greenland's Icy Mountains" is the beginning of a hymn which most of us have sung many a time in church or Sunday-school; but the reader may not know that often these mountains are actually floating on the waters of the sea, for most of the icebergs come from this land far up in the northern ocean—so near the North Pole that nearly all of its surface is covered with ice which formed, no one knows how many ages ago.

Had the geographer given the name Iceland to

fitting title, though its masses seem small compared with those of Greenland, for here the earth's surface is buried in an ice cap which the scientists believe to be fully 3000 feet—over a half mile—thick in the interior. From this cap extend numberless glaciers, which reach clear to the waters of the ocean, sometimes far into the sea.

We might call Greenland the world's ice-box. If you glance at the map, you will see that the State of New York, large as it seems to us, is not



A CURIOUS FORMATION OF AN ICEBERG, CAUSED BY MELTING.

this great region of the arctic, it would have been far more suitable, perhaps, than Greenland, for its smaller companion which lies between it and the continent of Europe has more vegetation; but when Iceland was first settled, its glaciers and snow-fields probably caused the hardy Danes who took possession of it to think this was the most

over one twentieth of the size of Greenland: for New York contains only 47,000 square miles. Then think that the glaciers are steadily moving away from the center of Greenland, really being crowded off the land, and it will not seem so strange that here is the birthplace of nearly all of the icebergs that are so feared by the mariner.

The manner in which the iceberg is formed is worth the telling. Physical geography explains

thick it has enormous strength, but finally the force of gravity conquers, the edge of the glacier breaks off and topples into the sea, and thus an iceberg is launched.



ROWING IN FROM AN ICEBERG.

how the glaciers work their way along the valleys in the earth's surface. As the interior of Greenland is much higher than the coast, many of them lie on slopes which of course incline toward the sea. The enormous weight of the ice mass forces it over the surface, even where the incline may be very slight. For many miles the shore rises abruptly from the ocean in steep walls of rock against which the waves dash. The glacier reaches the edge of the bluff and then is pushed over

glacier apart or, possibly, on one of those occasional days of the short Greenland summer when the sun's rays are warm enough, they weaken a portion which is thinner than the rest. So other bergs are formed to be caught in the ocean river and perhaps carried five hundred miles north from their starting-point until, drifting into the Labrador current, they float southward on the voyage from which none returns.

So if you are crossing the Atlantic and chance



A FLOATING "MOUNTAIN" FROM GREENLAND.

it. Perhaps it hangs above the sea for a distance of fifty feet or more, because if the ice is very

to see an iceberg glittering in the sunlight, you may think of it as a part of a glacier that is per-

haps a thousand years old. Well may it cause awe as well as admiration. Viewed from the ship's deck it seems a hundred feet or more in height, but the cautious captain usually steers a course that is some distance from the berg, for he does not know how much of it may be hidden below the surface. If you guess its top to be two hundred feet above the surface of the sea, you

den may project sideways or lengthways from the portion which is visible, and if the vessel ventures too near, she may strike the projection and be sunk, or "grounded" on the berg. This strange accident has happened more than once in the North Atlantic ocean. Sometimes a berg is grounded itself. Floating southward with the current, it may be carried into a part of the sea



A SCHOONER AMONG THE "GROWLERS," AS THE SMALL ICEBERGS ARE CALLED.

may not be far wrong. Some have drifted past the city of St. Johns, Newfoundland, that were nearly as high as the hills that mark the entrance to its harbor, and icebergs rising two hundred and two hundred and fifty feet out of the ocean are not uncommon; but the captain has good reason to be cautious, for the mass that looms up so stately is but a small portion of the entire berg. If it is two hundred or three hundred feet high, it may reach a thousand feet below the level of the sea. If it is very high in proportion to its length and thickness as seen above the water, it must be enough submerged to keep it from toppling over, for, as is well known, ice contains so much air that it is very buoyant, therefore the part submerged acts like the ballast in a ship. It helps to keep it upright. The part which is hid-

den where its bottom strikes the ocean "floor"—the bottom of the sea. There it is held perhaps for months, until the melting of the upper part causes it to rise sufficiently to clear the ocean bed, but it may be disengaged by the waves of a storm which heave it from its resting-place.

As we see them at a distance, these ice mountains from Greenland's coast are very picturesque, especially when their sides reflect the rays of the sun. The ice may not seem as clear and as pure when you come close up to it, but seen a half mile or a mile away it is a sight to be remembered by the one who has never before witnessed it. In shape it may seem like a mountain—slopes and summit being perfectly outlined. Fancy may shape another into a cathedral from which glittering spires arise. Another looks like a vast block of

granite or marble just after it has been taken from the quarry. Seen from another point, it may bring to mind a crouching animal, such as a lion or a dog or a walrus. Nature molds the masses with the aid of the wind and sun.

As they get further and further southward, the warmer air rounds off the sharp corners and makes curves of beauty. They do not look so rough and jagged as when they begin their journey, but this glacial ice is much harder than that which forms on the surface of the sea or lake.

of glaciers have split off and fallen into the water,—these boulders are often held in their embrace. It is a curious fact that many huge stones found on the coast of Labrador and Newfoundland have been carried to their final resting-place all the way from Greenland imbedded in icebergs that stranded or grounded on these shores.

Melville Bay, Greenland, named after Admiral Melville, the celebrated arctic explorer, is almost surrounded by glaciers, some of which reach back into the interior a distance of twenty-five miles;



"LIKE SOME GIANT ANIMAL."

Constant pressure upon it as the glacier has been crowding its way to the sea, has made it dense, compact, just as hammering and pressing make the iron bar harder and stronger.

But on looking at the iceberg through the marine glass or telescope, its walls may appear dark. Perhaps you see black objects in them. These are parts of Greenland which it has carried away, either to drop into the sea as it melts, or deposit on the shore, if it should be stranded, and there dissolve. As the glacier moves seaward at the rate of an inch or a foot a day, it really pushes through the earth and softer rock, carrying this sediment along, the mixture being what is called the moraine. The dirt and stone sink into the interior of the ice mass. So some of the larger glaciers reaching that arm of the ocean known as Melville Bay, have brought to it boulders weighing a ton or more, and when overlapping edges

but there are a number of bays or what the Norwegian would call fjords also on the west coast that pierce the land for fifty miles, and many icebergs come from them as well. The bergs which go around Cape Race and pass Newfoundland have been partly melted by the warm, moist winds which blow from the southeast against their sides. In spite of their dimensions, most of them are small compared with the enormous masses that float out of Melville Bay and the other inlets. Arctic explorers have seen some which were fully five hundred feet high and several miles around at the point where they rested in the water—actually ice islands in size.

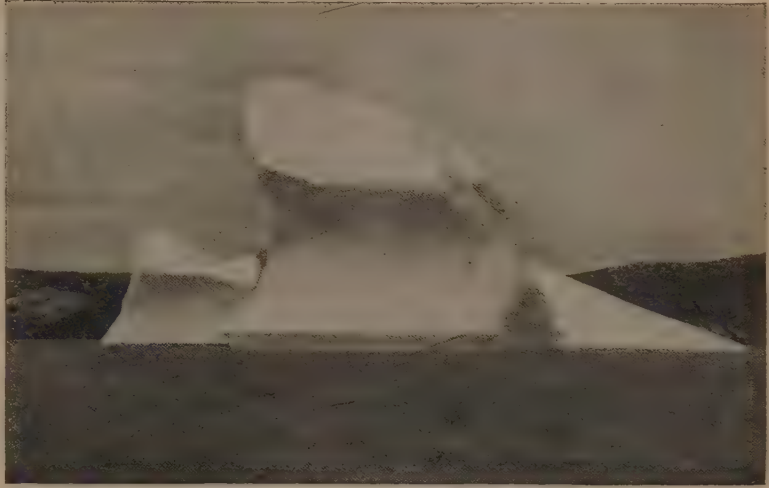
When an iceberg breaks away from a glacier, it sounds like the report of a heavy gun, and may be heard for miles, while its fall into the water produces waves which roll from shore to shore of the bay. The sound caused by the breaking of

the ice in one place frequently causes other ledges to break off. It is supposed that the vibration of the air due to the sound waves produces this effect, just as an avalanche of snow is sometimes started down a mountain merely by a shout or the ordinary tone of the voice.

It is a long voyage which the bergs make before they disappear to mingle with the waters of the Atlantic. Nearly all of the year they are floating away from Greenland's western shores, first taking a course which carries them as far north as the 75th parallel of latitude. Glance at the map and you will see that this is near the great source of the bergs,—Melville Bay. Then they swing westward and, coming down the mainland of North

America, skirt the bleak, bare shores of Baffin Land and Labrador, sometimes blocking up the straits of Belle Isle that divide the Labrador peninsula from Newfoundland. In the late summer and early autumn, the stately procession of icebergs can be

be visible at one time. To study their massive walls it would seem as if they defied Nature to melt them,



RESEMBLING A BLOCK OF HEWN MARBLE.

but when they get as far south as Newfoundland, they decrease more and more rapidly in size, finally becoming "baby" icebergs, twenty or thirty feet in height, which frequently drift into harbors or continuing southward, finally disappear in the



A VERITABLE ICE-MOUNTAIN.

seen to the best advantage from the shores of England's oldest colony. Some days only one or two may come in sight. On others a half dozen or more may

ocean. Their graveyard seems to be in the Atlantic about four hundred miles south of Nova Scotia. Here the water is of such a temperature

that they melt below as well as above the surface. The sailor dreads these glacial islands, not only because his craft may strike one and be

The boat is moored to its side and the men cut off chunks which are taken to the vessel and melted down in a steam boiler. Where water is scarce in the coast towns the "baby" bergs are used for a supply.



THE SKELETON OF AN ICEBERG.

sunk, but because they change in size and shape far more rapidly than one could imagine. A berg which appears to be as solid as a mountain may become top-heavy and fall into the sea, crushing anything that is near it. Sometimes a venturesome fisherman will attach his boat to an iceberg by means of a rope if there is no wind, and let it tow him southward toward the fishing-banks, but he is taking a great risk in doing so. The smaller bergs, however, afford a supply of fresh, pure water, for the glacial ice is not salt. So when the skipper chances to be "short" of water it is a common thing for him to steer for the nearest iceberg and send a boat and crew alongside of it.

These hummocks are very dangerous, however, and many a craft has gone to the bottom of the sea by striking one of them. Sometimes pieces of the pack are separated from it, forming sharp-edged cakes which are mostly under water. These "growlers," as the seaman calls them, when tossed about on the waves are as much to be feared as the icebergs themselves, for they are so heavy that they deal a hard blow when dashed against the ship's sides, and their sharp, jagged sides will cut through the stoutest timber, even the copper which may sheathe the outside of the craft. Steamship passengers often like to see icebergs; but to the captains and navigators they are never a welcome sight.



IMPRISONED IN AN ICEBERG

BY C. F. HOLDER

"SAIL ahoy!" came a shrill hail from the fore-top of the trim bark "Laughing Polly," as it bowled along in the latitude and near vicinity of the South Shetland Islands.

"Where away?" answered a tall man with a tremendous voice, who was pacing up and down the quarter-deck, muffled in a great pea-jacket.

"Dead ahead!" came the voice of the lookout, who was the captain's son. He had taken the watch so as to be the first to sight land after the long run to the south.

The captain swung himself into the rigging, gave a glance at the supposed vessel, and then dropped to the deck again with a loud laugh. "Your ship is an iceberg," he called out. "A pretty sailor-man you are," he added, "not to tell an iceberg from a whaler."

"I can see her spars," shouted back the boy, who would not acknowledge his mistake; and indeed the nearer they approached, the more the object appeared like a vessel on the same course as themselves. It seemed a veritable ship, careening slightly in the brisk breeze. There were the white top-sails, with the shadows on them distinctly visible, and Ned—for that was our lookout's name—almost thought he made out a pennant at her mizzen-peak. So remarkable was the sight that the sailors all gathered in a group forward, and watched the strange sail. But on getting within a mile of it, they plainly discerned that it was an iceberg of enormous dimensions, and which, even at that distance, seemed to tower above them. Its resemblance to a ship was quickly lost, and it loomed up, a great mountain of blue ice, momentarily changing its shape and color.

The captain had just given orders to shift the course of the vessel, when a cry of astonishment rose from the crew, who were still watching the distant berg. The captain and mate rushed forward, and saw the cause of the excitement. The ice-mountain had changed its position, and instead of being upright was heeling over. Faster it moved, until finally, fairly overbalanced, it fell over in the water with a mighty crash, hurling into the air great waves three times as high as their masthead, and sending out huge rollers on either side, while vast blocks of ice seemed to break off and float away.

"It's gone," shouted Ned, excitedly.

"No, it is n't," said his father. "Just keep your eyes on it."

The words were hardly spoken by the captain before a still more remarkable phenomenon occurred; the iceberg appeared gradually rising from the sea, slowly resuming its original shape, like an island of ice being forced above the surface by some invisible power. Slowly but perceptibly it rose, until finally the astonished sailors saw the gigantic berg, almost as large as before, rocking and oscillating, again upright upon the surface.

In the meantime a series of waves from the scene of action had reached them, and Ned was nearly thrown from the foretopgallant-top, where he was still clinging. The ship pitched so violently that it seemed almost as if they had experienced a series of tidal waves.

"It's only an upset," said the captain, as Ned rejoined him on deck. "You see, one of these great bergs floats about until it gets top-heavy, which is occasioned by the lower portion, a thousand or fifteen hundred feet below, striking, perhaps, a warm current that melts it away, until finally the exposed portion overbalances the base, and over it goes with a thundering crash, as we have seen."

"I had no idea a berg as large as that could tip over," said the young sailor.

"I have seen larger ones than that roll," replied the captain. "There seems to be no limit to their size. An iceberg was observed some years ago, not four hundred miles from here, that was two and a half miles long, over two miles broad, and a hundred and fifty feet high, and it must have weighed fifteen hundred million tons. Yet that was by no means a large one. I have seen them off Cape Horn nearly eight hundred feet high; and a mass of icebergs was once seen sixty miles long by forty broad, and three hundred feet high. As only one-tenth of the whole mass rises above the water, the higher out of water, the larger they are, and one which exposes two hundred feet would probably have eighteen hundred feet under water."

The conversation was here interrupted by a hail always welcome on a whaler. Whether it was "There she blows!" or "Whale o'!" they could not make out; but seeing the lookout pointing toward the floating island, they turned that way.

The vessel had suddenly passed a projection of the berg that showed them its broad side and snowy peak looming three hundred feet into the



THE WHALE WITHIN THE ICEBERG.

air, and near the top, frozen in the icy block, was the black body of an immense whale.

"Never mind the boats," said the captain, recovering from his astonishment, and recalling an order which he had given upon hearing the hail. "Well, that beats all my experience in thirty

years' whaling," he continued. "A finback in an iceberg!"

"A frozen whale in command of a ship of ice," said Ned. "And to think that we saw it rise three hundred feet from the water!"

"It's the greatest leap on record," exclaimed

his father, "and as such jumps don't occur every day, we may as well have a nearer view"; and, instructing the helmsman, the whaler was hauled a point or so on the wind. It was soon found, however, that a nearer view of the whale would involve being becalmed in the lee of the berg, so the boat was lowered, and the captain and Ned were soon being pulled toward the huge prisoner of the ice-island.

As they approached, the sight became still more remarkable and impressive. The sight was very tantalizing to the whalers, as there above their reach was the game they were in search of; but it was out of their power to dislodge it from its bed of ice, and they reluctantly rowed back under the shadow of the berg. Looking up at the imprisoned whale, they saw that it was a rorqual nearly one hundred feet in length—the largest of living animals.

As the wind had died down, they could not leave, and so they witnessed the effect of sunset on the ice-island. The tall peak was flooded with golden lights; dark shadows crept up its sides, gradually changing the golden radiance to gleaming silver, then to gray, which was in turn lost in the approaching gloom. But soon the moon appeared, bathing the berg with its silvery light and bringing out with startling distinctness the frozen giant.

Late into the night the sailors watched the island of ice, fearing that perhaps the surface current might bring them dangerously near it, but finally the wind sprang up, the sails filled, and the frozen whale was soon lost in the distance.

Upon the return of the whaler, two years later, the story was told, and it was found that several

sea-captains had observed similar sights. One had seen a polar bear so imprisoned, while others told of enormous rocks and boulders that the bergs lifted from the sea. The presence of the whale in the berg was explained in a remarkable way. The huge animal was not entombed at sea, but it had been washed up on the thick ice-sheet in the lee of some antarctic island (these sheets sometimes extend many miles from shore); the snow from the shore had blown over it year after year, melting and freezing, until finally it was surrounded by hard, clear ice; the weight, ever increasing, forced the sheet under water, and as the snow was continually piling up on the top and changing to ice, the great mass with the imprisoned whale finally projected far out under the sea. The snow continued still melting and freezing, but piling upward. And then its weight, or perhaps a heavy gale, detached the mass from the field, and it floated away, an island of ice, bearing the captured whale beneath the sea.

As we have seen, the warmer currents wore away the submerged portion until the berg became top-heavy and overturned, bringing the long-imprisoned monster high up in air.

Sometimes, instead of being frozen in and carried to sea, whales are forced far inland. Captain Pendleton, who accompanied one of the United States expeditions to the Antarctic Sea, saw a whale two hundred and eighty feet from the surface of the water, in an ice-cliff eight hundred feet high. Whales and their skeletons have not only been found above the level of the sea at South Shetland, but a mile and a half inland away from the shore—wonderful examples of the power of frozen snow and water.

WATERSPOUTS AT SEA

BY J. O. DAVIDSON



HO has not noticed, during a sultry summer afternoon, the little whirlwind in the middle of the dusty road, caused by two breezes coming down streets that come

together? First there will be seen a column of light dust revolving upward; next, moving here and there, it picks up stray bits of paper and

leaves; then, as its whirling grows stronger and covers more ground, it adds to its strange collection of objects small sticks and tufts of grass; at last away it goes, whirling and dancing its elfin waltz until some immovable object interferes with its freedom of movement, when, like a spoiled child, it ceases its wild play, the whirling stops, and—pouf!—down come the sticks and leaves and paper, and the whirlwind is gone. In the Western States the same kind of whirlwinds grow to such proportions that through the thickest woods great tracks are mown as if cut by a giant scythe. But these big storms very appropriately receive the more dignified name of tornadoes.

On the ocean, these whirlwinds or tornadoes have, of course, no dust or trees to toss about in their giant hands, so they seize upon and suck up the water as the only plaything they can find, and, twisting it into a long glittering rope of trembling liquid, lift it up to the clouds, whence it is soon dispersed again in the form of rain. When performing such antics as these, the whirlwind or tornado is known as a waterspout.

The ship's crew which has so patiently steered its craft by treacherous rocks, over dangerous shoals, and through all kinds of storm and stress at sea, is often confronted by a new and unex-

visitors, who fly hither and yon at their own sweet will, minus rudder or pilot. I have seen a waterspout make for a large fleet of rice-junks, and the scattering of the queer-looking craft under their brown sails and dashing sweeps looked comically like the flight of a flock of startled quail.

Sometimes a spout can be broken by the firing of a cannon close by; and then the singular spectacle will often be presented of the upper half of it going up into the clouds, while the lower part subsides into the sea. As most Chinese junks carry a number of guns and gongs, the water-



"THE BROKEN COLUMNS OF WATER DROPPED IN TONS ON THE FORWARD DECK."

pected danger—the waterspout. It most often makes its appearance beneath a black and lowering sky; but sometimes they start up mysteriously in clear weather to move along the ocean's rim in queer fantastic attitudes, looking for all the world like captive balloons dancing up and down, and tugging at their ropes—now near the sea, now near the sky.

In the Strait of Malacca, and among the many islands in the China Sea, they are greatly dreaded by the peaceful fishermen, who must often pull up anchor and race for the shore to avoid the unwelcome approach of these giddy

spout often gets the worst of it in the uproar that is certain to salute one.

The great four-masted American sailing ship "Shenandoah," while coming home from Liverpool once, had a lively experience with waterspouts. When she got within five hundred miles of Sandy Hook, the wind suddenly changed, a great bank of clouds just ahead parted, and there, coming down, driven before the gale, appeared six great waterspouts at one time.

One rushed by, just clearing the bowsprit and head-sails by a few yards. Another came at her amidships, threatening to carry the mainmast

away, and the captain just avoided by quickly turning the ship toward and around it. There were two more near ones, and as they were too close to run away from, the big ship was "luffed" up and steered right between them. The ship was saved, but what her fate would have been had she been struck by one can only be imagined from the captain's description of the waterspout that passed astern. He said it seemed to be fully twenty feet in diameter, and of solid water reaching to the clouds.

On another occasion the steamer "Piqua" had a still more uncomfortable experience with these wandering giants of the ocean, near the Bermuda Islands. There she met a cyclone upon whose outer edge there hung a great number of spouts—all dancing and pirouetting here and there; twisting and turning and balancing to partners as if engaged in an elephantine quadrille.

The captain became bewildered, for whichever way he turned his steamer, he was headed off by the surrounding waterspouts. At last, just as he

imagined he had steamed safely away, two of them made a rush, headed him off, and struck the starboard side of the steamer's iron bow a tremendous blow. Then there was a commotion indeed. The broken columns of water dropped in tons on the forward deck, smashing the pilot-house and bridge-ladder, tearing down thirteen ventilators, and dashing to the deck two sailors badly wounded. The ship staggered and rolled as the weight of water poured over her sides in a Niagara of foam and spray, and for some time she could make no headway.

While the two spouts were having their frolic with the sorely beset steamer, the others were whirling about as if dancing in glee at the commotion they had caused. From the black clouds above there shot down blinding streaks of lightning, which, although they missed the ship, so filled the air about her with electricity that it settled upon the metal tips of all the spars, glowing and sparkling there steadily with the beautiful light known as "St. Elmo's fire."

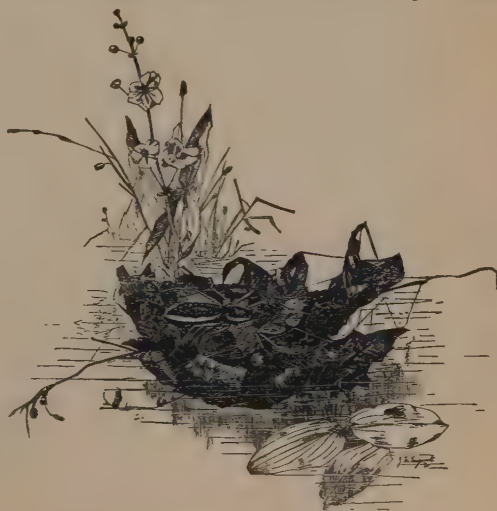
SOME CURIOUS MARINERS

BY C. F. HOLDER

ONE bright spring morning, two boys were walking out into the open country, near the little village of Cowes, on the Isle of Wight. Each lad carried under his arm a miniature cutter. It was the day of the great race between the "Sea Mew" and the "Prince Albert," the reputations of which, as winning cruisers, had been earned in many a hard-fought battle on the pond then in sight. A number of boys were already at the shore, and their boats, beating up and down the lake, gave it a very animated appearance. As Ralph and Dick approached, bringing the champion cutters, all the competitors moved to the head of the lake, and soon the signal for the race was given. The "Sea Mew" and the "Prince Albert" got off first; then came the smaller boats; while following up the race, some in a skiff and some along shore, the boys shouted and cheered the imaginary skippers of the various craft, who, it must be confessed, sailed them in a rather curious way. As the "Prince Albert" rounded the stake on the home-stretch, a queer personage came aboard. The boys were allowed to put their craft about, and Ralph had waded out and was just about to stop his boat, when it came in collision with a floating mass of leaves that threw

it up into the wind. From the wrecked leaves nimbly darted the only survivor, a large spider, so alarmed at the catastrophe that it reached the crosstrees of the "Prince Albert" before it even looked about it.

"The 'Prince' has been boarded by a ship-



THE SPIDER AND HIS CRAFT.

wrecked crew!" shouted Ralph, giving the mast a rap that sent the spider to the topmast-head.

"Let him stay," said Dick, picking up the leaves that now floated by. "You ran him down, and now you must take him ashore, or we'll treat you as they did the man in America who was tarred and feathered and carried in a cart."

So the spider was taken back by the cutter to the starting-point, and it must have brought good luck to the cutter, for the "Prince Albert" came in ahead and won the "cup," as the boys called the old-fashioned blue soup-tureen, ornamented with figures of Neptune and dolphins. And within this receptacle the shipwrecked spider was carefully placed after the race was over.

"Here's his craft!" said Dick. "Let's put it in some water and see if he'll take to it again."

So the "cup" was filled and the layer of leaves thrown in, when the spider, without a moment's hesitation, leaped into the water from the side of the tureen—or "cup"—and soon clambered upon the leaves, much to the amusement of the young yachtsmen, who had gathered around to see what it would do.

In this manner, Dick and Ralph carried the spider home to Dick's father, who told the boys, much to their astonishment, that it was a ship-building spider.

dentally caught together, but that the leaves have been drawn carefully one over another, and fastened together by silken cords, forming a perfect boat?"

The boys soon saw that this was indeed the fact, and, much interested, they started out next day, determined to become better acquainted with these nimble little boatmen. They were amply repaid for their trouble, for they had not gone far when Dick cried:

"Here is one, Ralph!" In a little bay, Dick had discovered a small bunch of leaves whirling round and round, and lying closely upon it a large and handsome spider that might easily have



THE SPIDER BUILDING HIS BOAT.

"Examine the leaves more closely," he said. "Don't you find that the bunch has not been acci-

been the First Lord of the Admiralty of the Spider-Queen's navy. Around its brown body was a band, or sash, of rich orange color barred in a curious manner; while a double row of white spots upon the under side, Ralph said, represented its rank. Its legs were a light red—and altogether its outward coloring made up a very fanciful and appropriate uniform.

But I grieve to say that the spider was really a pirate of the boldest and most cruel type. Finding that the circular motion was caused by the peculiar way in which the turned-up tip of a leaf caught the breeze, Ralph gave the craft a start,

and away it went before the wind, the red-legged skipper lying low for plunder.

Near the head of the pond several members of the *Dolomedes fimbriatus* family (for this is their scientific name) were found, and the boys came upon one fellow in the very act of starting out on a voyage.

By lying upon the bank and keeping very still, the lads finally gained possession of many secrets of this cunning ship-builder. At first the spider seemed to be looking for something in the grass near the water's edge; finally, he seized upon a dead leaf, which he dragged down a slight decline, where the boys now saw several other leaves collected. By deft movements of his long legs, the leaf was lifted and tucked in between the others—the builder lashing them together by silken cords which he spun, and fastening them by a simple pressure of his body against the leaf. This leaf being satisfactorily placed, another was brought, and the same process repeated, the creature running rapidly about, passing silken cords over the entire mass, and now and then raising himself up and down, as if testing the strength of his craft. The vessel gradually grew in size until it was an inch and a half thick and four inches across, when it seemed to satisfy its owner.

The spider now ran down to the water several times, returning every time thoroughly to inspect the vessel; finally, taking the craft in his strong mandibles, or jaws, he drew it several inches toward the water. Then, resting for a moment, he took it a second

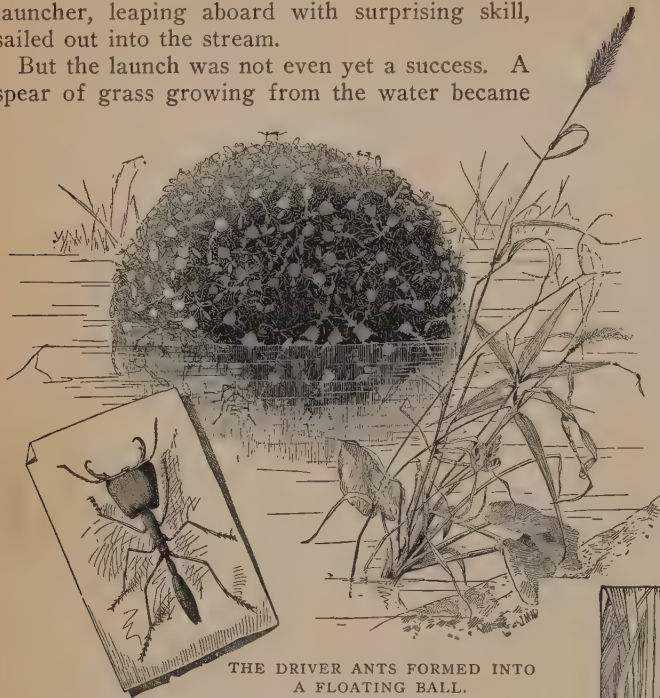
time by the side and drew it fairly to the water's edge. Once there, he took a last hold, the leafy



THE SPIDER THAT LIVES UNDER WATER.

ship glided clear of the shore, and the gay launcher, leaping aboard with surprising skill, sailed out into the stream.

But the launch was not even yet a success. A spear of grass growing from the water became

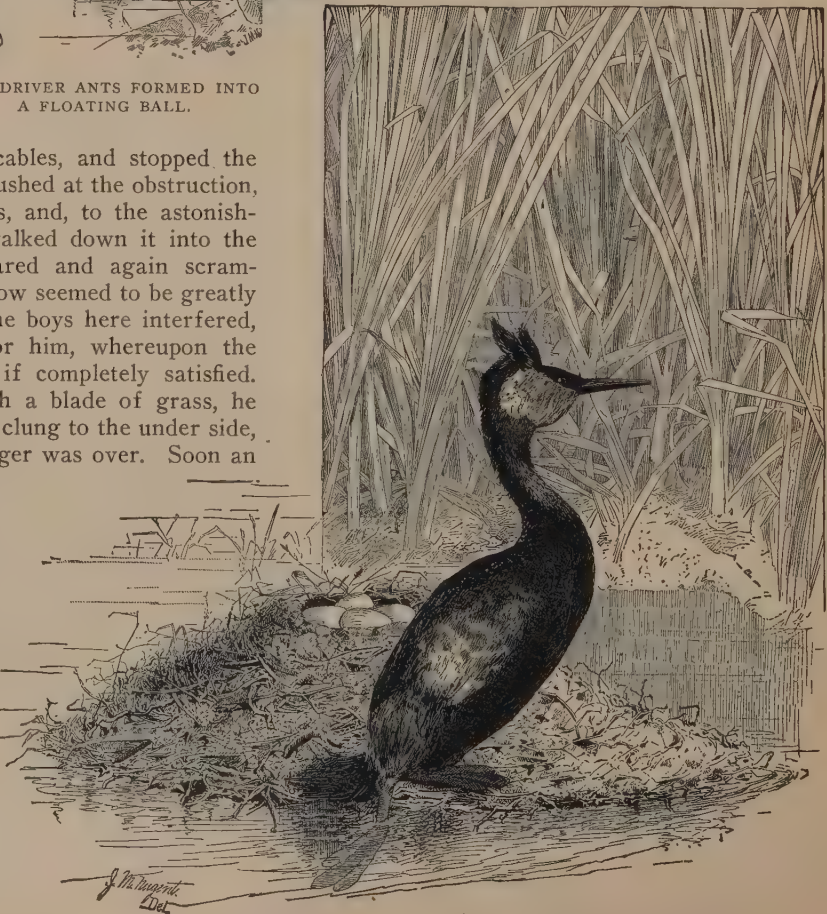


entangled in the silken cables, and stopped the fairy craft. The spider rushed at the obstruction, seized it in his mandibles, and, to the astonishment of the watchers, walked down it into the water. Soon he reappeared and again scrambled aboard. But as he now seemed to be greatly agitated and disturbed, the boys here interfered, and cast off the raft for him, whereupon the skipper settled down as if completely satisfied. If they touched him with a blade of grass, he darted into the water and clung to the under side, coming out when the danger was over. Soon an unfortunate fly alighted near the raft, when the pirate, instead of rowing his boat alongside, actually dashed into the water to secure his victim, swimming back to the raft to devour it at his leisure. The last the boys saw of the spider, he had jumped again at something that rippled the water; but he never returned. Possibly a self-satisfied young frog that soon hopped upon the bank could have ex-

plained the absence of the skipper of the now deserted craft.

Thoroughly interested, the boys repeatedly watched the spiders, and studied their manners and their labors. They found also another spider, which, although it did not make a raft, had no fear of the water, and frequently went fishing; while Dick's father told them of still another that lived under water by carrying down bubbles of air with it. Its home, too, might be called a queer diving-bell, as may be seen from the illustration.

There are certain ants that show quite as much intelligence as the spider, and the "driver ants" not only build boats, but launch them, too; only, these boats are formed of their own bodies. They are called "drivers" because of their ferocity. Nothing



THE GREBE AND HER FLOATING NEST.

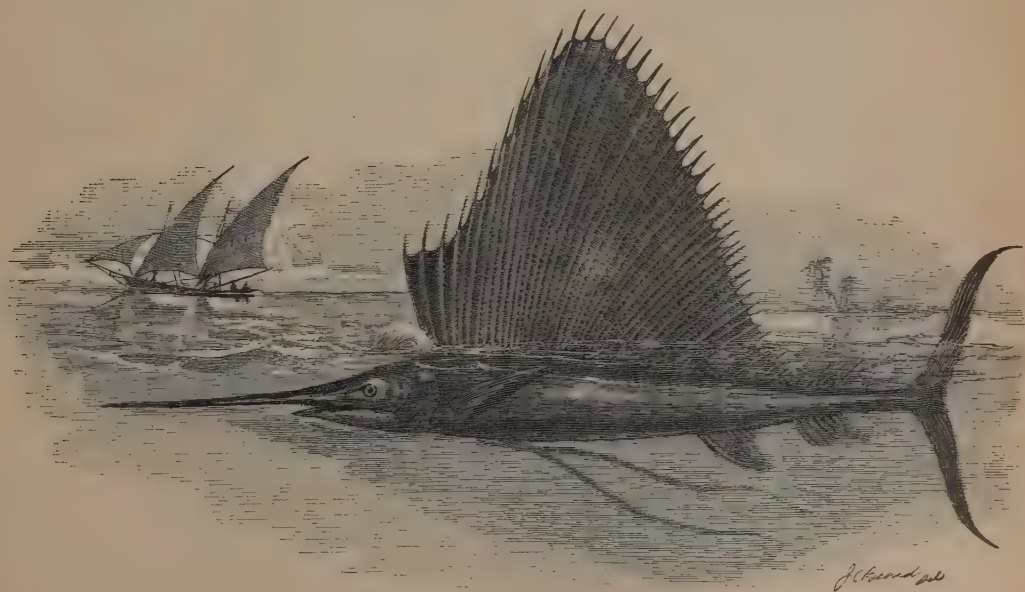
can stand before the attacks of these little creatures. Large pythons have been killed by them in a single night, while chickens, lizards, and other animals in Western Africa flee from them in terror. To protect themselves from the heat they erect arches under which numerous armies of them pass in safety. Sometimes the arch is made of grass and earth gummed together by some secretion, and again it is formed by the bodies of the larger ants, which hold themselves together by their strong nippers, while the workers pass under them.

At certain times of the year, freshets overflow the country inhabited by the "drivers," and it is then that these ants go to sea. The rain comes suddenly, and the walls of their houses are broken in by the flood, but instead of coming to the surface in scattered hundreds and being swept off to destruction, out of the ruins rises a black ball that rides safely on the water and drifts away. At the first warning of danger, the little creatures rush together, and form a solid ball of ants, the weaker in the center; often this ball is larger than a common base-ball, and in this way they float about until they lodge against some tree, upon the branches of which they are soon safe and sound.

One would scarcely look for ship-builders among birds, so many of which are boats in themselves, going either upon or under the water; but in the curious family of grebes, one branch of which produces the beautiful feathers so coveted by ladies, there is one kind that forms a

nest which is a veritable ark. Instinctively these birds seek the low boggy marshes to build their nests. But there they are in continual danger from the high tides that often cover the marshes, or from the drift-wood which washes in, or from many other accidents. So the ingenious grebe, looking like a clerk with feathery pens behind her ear, constructs a nest that will rise and fall with the tides, and can be moved from place to place. The boat is first built of rushes and grass; this is then packed with moss, and lined and relined until it is perfectly water-tight; and in this the eggs are laid. The home either is anchored to tufts of grass, or drifts, perhaps, here and there, though always guided by the mother-skipper, as she stands by the helm in all kinds of weather. We have seen that the spider is completely at the mercy of the wind, but the grebe propels her boat along. If the young are half grown, they readily take to the water; but if they are just hatched, the mother, at the approach of danger, steps upon one side of the boat, and uses one of her webbed feet as an oar to paddle away from the enemy into one of the innumerable inlets or lanes in the marsh, where she is almost sure to escape.

In the warm waters of the Indian Ocean a strange mariner is found that has given rise to many curious tales among the natives of the coast thereabout. They tell of a wonderful sail often seen in the calm seasons preceding the terrible hurricanes that course over those waters. Not a breath then disturbs the water, the sea rises and falls like a vast sheet of glass; suddenly the sail



THE SAILOR-FISH OF THE INDIAN OCEAN.

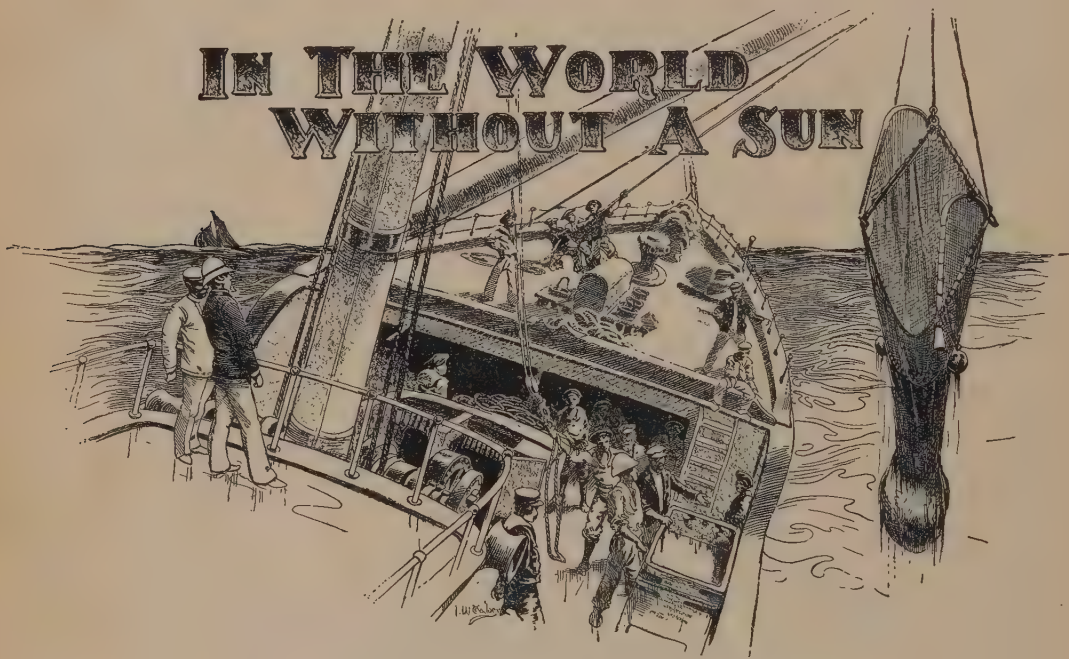
appears, glistening with rich purple and golden hues, and seemingly driven along by a mighty wind. On it comes, quivering and sparkling, as if bedecked with gems, but only to disappear as if by magic. Many travelers had heard with unbelief this strange tale; but one day the phantom craft actually appeared to the crew of an Indian steamer, and as it passed by under the stern of the vessel, the queer "sail" was seen to belong to a gigantic sword-fish, now known as the sailor-fish. The sail was really an enormously developed dorsal fin that was over ten feet high, and

was richly colored with blue and iridescent tints; and as the fish swam along on or near the surface of the water, this great fin naturally waved to and fro, so that, from a distance, it could easily be mistaken for a curious sail.

Some of these fishes attain a length of over twenty feet, and have large, crescent-shaped tails and long, sword-like snouts, capable of doing great damage.

In the Mediterranean Sea, a sword-fish is found that also has a high fin, but it does not equal the great sword-fish of the Indian Ocean.

IN THE WORLD WITHOUT A SUN



BY H. S. CANFIELD

AMONG the passengers on board the United States steamship "Petrel," detailed to make deep-sea soundings under the auspices of the Smithsonian Institution, were Professor George Crenshaw of the Smithsonian Institution and Robert Lessing, his nephew. Bob was recovering from typhoid fever, and his uncle had secured him the berth of "custodian of instruments." The opportunity for combining a health-giving cruise with the chance to earn a little money on so interesting an expedition was one not to be missed by the wide-awake boy.

The mission of the boat was to take soundings in the lower portion of the Caribbean Sea. She was small, trim, and powerful, and neat as a pin

from stem to stern. Her officers were a jovial and gentlemanly crew, and they took a liking to the pale, quiet boy who was never in the way, did not ask needless questions, and seemed anxious to bear a hand at whatever would be useful. The professor was in his element, telling stories, singing snatches of sea-songs, and overhauling the instruments for specks of rust. They went by islands whose "shores, like playhouse scenes, slid past their wondering eyes." They plowed waters of a blue almost dazzling. They sighted the Southern Cross, and that great constellation burned to the southward like a beacon. Then they slackened speed and began sounding.

The rope was made of thin wires; it ran from

a reel full of levers, wheels, and cogs. The reel had brakes on it to counteract the increased weight of the wire as it paid out the miles; it was screwed firmly to a stout platform built out from the side of the ship. Utmost care was taken to prevent the wire kinking, for when it kinked

registered the temperature, set itself, and stayed set. There was a little box which opened itself at the bottom, filled itself with sea-water, and shut. There was a valved tube which collected mud or sand. There was a cylinder which registered the pressure of the water; sometimes it was



A GLIMPSE INTO THE WORLD WITHOUT A SUN.

it broke; otherwise, as the professor said, "it would hold a buckskin mule with black stripes around his legs." The weight to carry the wire down was attached to its end, and when bottom was reached this weight came off automatically and stayed down forever. Here and there above the weight instruments were attached. One of them was a thermometer, which did not act until it was within three feet of the bottom. Then it

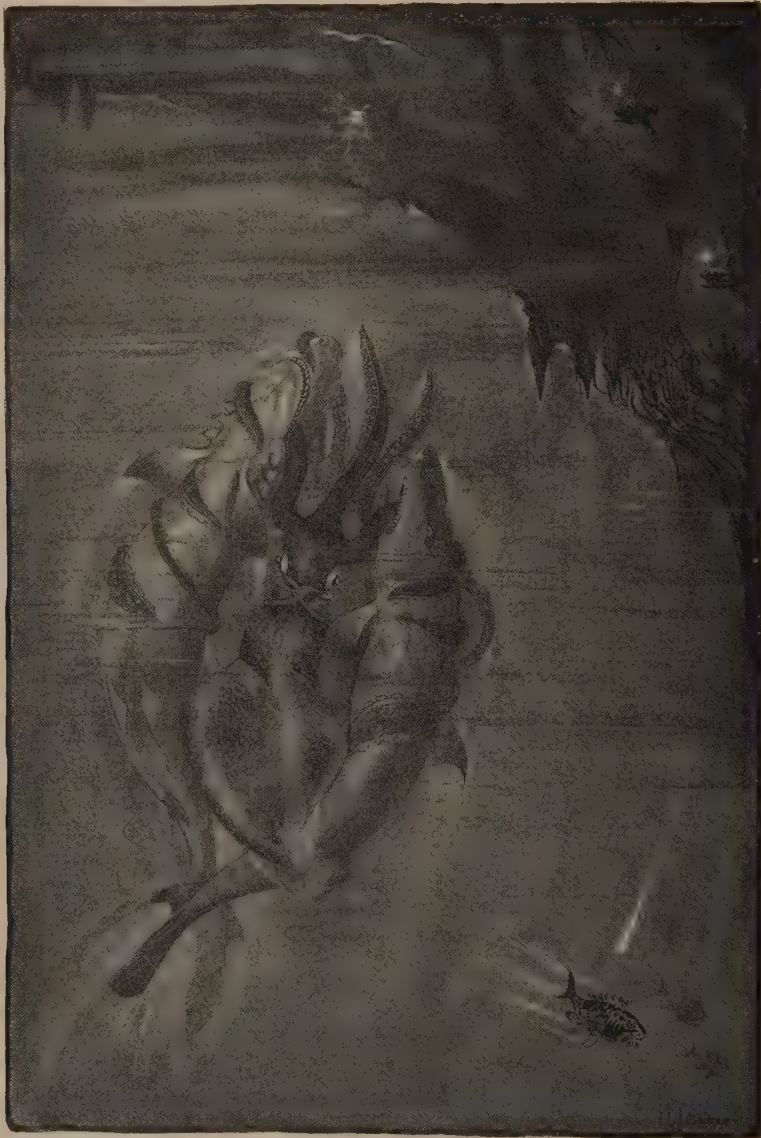
as high as eight thousand pounds to the square inch.

"That pressure," said the professor, "would thin a man out like a pancake."

The "Petrel" was not only a sounder, but a fisherman, and it was this work which the professor was superintending and recording. When it began he was busy from morning until night, and had no time for jokes except such as forced

their way out of him in spite of himself. He had great alcohol-jars in which the smaller specimens were preserved, and he walked around the bigger ones as they sprawled, and measured them and photographed them and examined their

On the deck were large steel drums with cables wound about them, and these pieces of intricate machinery let down the weighted trawls by steam and hauled them up. Once they were down, the "Petrel" either steamed at one-eighth speed or



A DEEP-SEA COMBAT.

tissues in steady delight. He told Bob that the work was of exceptional interest, because scarcely a haul was made in which he did not see something that no man had ever seen before, despite the fact that deep-sea fishing had been going on for years, so vast is the ocean floor and so innumerable the varieties of the inhabitants.

drifted on the current, and after a while the strain was put on and the drums began to turn slowly in the uplift. At first the engines groaned, because the steel nets always became half sunken in the soft bed; but as they came up, the water washed the mud from their meshes, and they reached the vessel's side clean and alive



with the most wonderful squirming or flapping things. Never a man in his wildest dreams had such visions as those which confronted the watchers on the "Petrel's" deck.

Bob got an object-lesson one day in the meaning of sea-pressure. The sounding-wire had been let down, with a hollow metal sphere attached just above the sinking-weight. This sphere was a foot in diameter and made of finely tempered steel. The wire was wound in, and not twenty feet away the fishing-trawl was also coming in. They reached the surface simultaneously as he peered over the side. The steel sphere had been mashed into a thin disk and one of its edges rolled over in a cylinder. In the trawl were half a dozen specimens of deep-sea life, and one of them, as it came into the air, blew up like a toy balloon. This fellow had been taken about half-way up, and being used to a pressure of some thousands of pounds to the square inch, had naturally expanded rapidly when that pressure was released.

"We have brought up thousands of species," said the professor one day, in a lecturing mood, "but the government cannot hope to secure a specimen of each of the varieties, for they are too many; nor can we hope ever to capture any one of the larger kinds. They are so enormous that we could not handle them if they were caught. We know enough about the world down there, however, to know that if man could visit it, all of the wonder-stories written since time began would seem tame

beside the marvels unfolded. No human imagination is equal to picturing even the least grotesque of those forms; we need them actually before us to appreciate them; and each haul of the net produces things which seem only outrageous contortions of nature. There is no sun in those abysses under miles of water, not a ray of our light ever pierces to the entrances of the vast caverns; yet there is a strange and ghostly light made by the fishes themselves, and if we could see it, we would seem to be in a land haunted by gleaming specters of the horrible. Passengers in great steamers plow merrily only a mile or two above monsters that would send them into spasms of fright if they could be seen close at hand. The deepest haul of a net ever made in the world was achieved by Americans off the Tonga Islands in the South Pacific. The trawl struck bottom twenty-three thousand feet below the surface; that is considerably more than four miles down, but even at that depth animal life was found. Those strange beings lived in water whose temperature was constantly just above the freezing-point, and under a pressure of nine thousand pounds to the square inch. To sink that net and bring it back again took a whole day of steady labor."

As a rule, however, the professor was too busy to lecture. When waiting for the net to come up he was making notes, or writing reports, or bottling specimens, and once the haul was on deck he was a man possessed by a quiet frenzy. Discoveries wrung grunts of joy from him as he potted about, and he



seized the commoner fishes and threw them back into the waves, saying in unprofessional language: "Get out! You 're as common as pig-tracks!"

Bob saw cuttlefish with six, seven, or eight arms; these last were the octopuses, but he did not eat any of them, though the black cook took some of the squids and made delicious dishes of them. The professor said that these specimens were sextopods, septopods, and octopods; but the Latin names did not make them more inviting, or lessen the glare in their cruel black eyes.

Sometimes the net brought up coal-black things that were all mouth, with teeth fringing the gap from end to end and bent backward like curved spines; sometimes there would be a great glaring single eye, with a little mouth under it, and a little tail running away from it; sometimes a huge disk, three feet in diameter and half an inch thick, would be the chief occupant of the steel meshes—a disk with no apparent means of locomotion, having no fins or tail or visible muscles. Fish that were all curves and fish that were all angles came up; round fish, square fish, fish of bones and scales, fish of flabby, defenseless flesh; fish of the most weird forms and hues. There were sharks seven feet long and sharks seven inches long; some of the fish were shaped like pigs and some like serpents; some of them had strangely human expressions of face, and some had faces more terrible than those of the gross beings in Doré's illustrations of the "Inferno." Of devil-fishes and squids alone there were hundreds of different kinds; some of these floated through the water like milky clouds, and at great depths emitted steady halos of light like electric lamps in a drizzle.

But it seemed to Bob, when he had grown rather more used to these monsters, that it was in adapting and placing the eyes that Nature had played her very strangest pranks. They caught one fish far down in the Caribbean that had no eyes at all, nor any places for eyes, but long antennæ ran out from its nose by which it felt its way and found its food. In the next haul was a fish with two convex lenses in place of eyes. These lenses were highly polished, or burnished; they were of a golden hue, and they gleamed in the sunlight like jewels. Another fish, a big fellow, had eyes which grew on stems, or stalks,

that stuck out six inches from its head. Then came one with an eye that grew on a long stem like a lily-stem, quite eighteen inches from the nose, and the professor said that it was an eye made for poking itself into other fishes' business. The stem was flexible and waved backward and forward, or bent with its own weight; and sometimes the fish traveled with the eye doubled under it about the middle of its body, or trailing in the sand or mud. Some of the eyes when put into sea-water in the dark shone like lanterns; others of the fishes had brilliant spots along their sides that emitted a ghostly radiance, and they seemed to have lighted port-holes, or windows, like a slender steamer rushing through the seas after night.

Bob noticed that the skipper and officers seemed proud of the efficiency of the nets, and particularly of the sounding-apparatus, and he knew why, one day, when the skipper pointed at the reel with its wire and said:

"That is the work of one of our boys. His name was Brooke, and he was a middy at Annapolis, hailing from Virginia. It was away back in 1854 that he made a deep-sea sounding-rod, but it was so ingenious and so correct that all deep-sounding apparatus of the present day is based upon it. Other fellows improve it now and then—American fellows or foreign fellows; they put in a cog here or a ratchet there, but it is Brooke after all. He made the key that unlocked that black world down below us."

So the days went on, and Bob saw many things that he will remember as long as he lives. Strange, weird lives faded and went out under his eyes; strange bits of coral fascinated him; rocked on the ceaseless swing of the southern ocean, he dreamed at night of its wonders.

At last the voyage was over, but his head was crammed with odd facts; he mentioned the names of mysterious creatures as familiarly as he had formerly talked of golf or ball; ruddy, insistent, triumphant health came to him in plenty. He was as brown as a berry and his eyes were crystal clear when he climbed down from the van which bore the professor's treasures and rung the door-bell of his own home.

"Mother," he said, when her arms were around his neck, "it has been like a dream—I have been in another world!"



WONDERS OF THE HEAVENS

THE SUN'S FAMILY OF PLANETS

WE are always glad to see the sun shining through our bedroom window on a spring morning, not only because it is warm and bright, but also for the reason that it heralds the approach of summer. The trees and plants are glad, too, when the sun shines on them, for it means new life to them, after the long and cold winter. The sun must therefore be a very important thing, and indeed it is, for we depend upon it for our very life; if it were not for the sun we could not live at all.

The sun is the center of what we might almost call "a family of worlds," and these worlds are called planets. Our earth is one of this family, and there are seven other worlds, besides the

earth, over which the sun rules. Each world, or planet, travels round the sun in its own path; some of these paths are near to the sun, others are farther away. The path of the earth lies a great way off from the sun, but yet not so far away as the paths of some of the other planets.

The sun attracts the planets, just in the same way as a magnet attracts needles, and this attraction, which is called gravitation, keeps the planets from wandering away from their paths. This family of the sun is called the solar system.

It has been said that each of the planets moves, or as astronomers say, revolves, round the sun. Most of the planets have, in their turn, smaller bodies revolving round them, and these small bodies are called satellites. Now you will understand what is meant when our moon is called the earth's

satellite. Besides this revolving round the sun, the planets have also another movement. You have all seen at school a big globe, fixed on a stand, on which is painted a representation of the continents and oceans of the earth. This ball is only held in position by a metal rod, which runs through its center, so that it can be made to spin round. This spinning movement is called rotation, and the rod is known as the axis of the globe. The globe is thus said to be rotating upon its axis. Each of the planets rotates upon its axis just in the same way as the schoolroom globe, but in their case the axis is not a real rod, but an imaginary one.

The order of the planets, commencing with the one nearest the sun, is as follows:

Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune.

So that we may be able to remember the proper order of the eight planets, let us learn the following sentence:



THE SUN, OCTOBER 19, 1905.

Men	Very	Easily	Make	Jugs
Mercury,	Venus,	Earth,	Mars,	Jupiter,

Serve	Useful	Needs.
Saturn,	Uranus,	Neptune.

We notice that the initial letters of the words of the sentence are the same as the first letters of the planets, in their proper order. Two of the names of the planets begin with the letter M, and in order that you may not get these two mixed up, the first word, standing for Mercury, begins with ME, like the planet's name, and in the same way the word corresponding to Mars begins with MA, to avoid all possibility of confusion.

THE SUN AND ITS SPOTS

THE sun itself is a very large globe, mostly composed of fiery gases. It is many thousands of times larger than our earth, and, indeed, than all the planets put together. Supposing we could lay a railway round our earth, and send off an express-train, it would travel right round the earth in less than three weeks; but if we could lay a similar railway round the sun, it would take an express train *five years* to travel once round it.

When we look at the sun through a telescope, there are often spots to be seen on its surface. Besides the spots there are streaky white markings called *faculae*, which is a Latin word meaning "little torches"; and this really is a very good name, because the *faculae* look just like torches as we see these at a distance.

In the first picture we have a beautiful photograph of the sun, taken October 19, 1905. Near the center of the picture we notice several large spots, forming what is called a group.

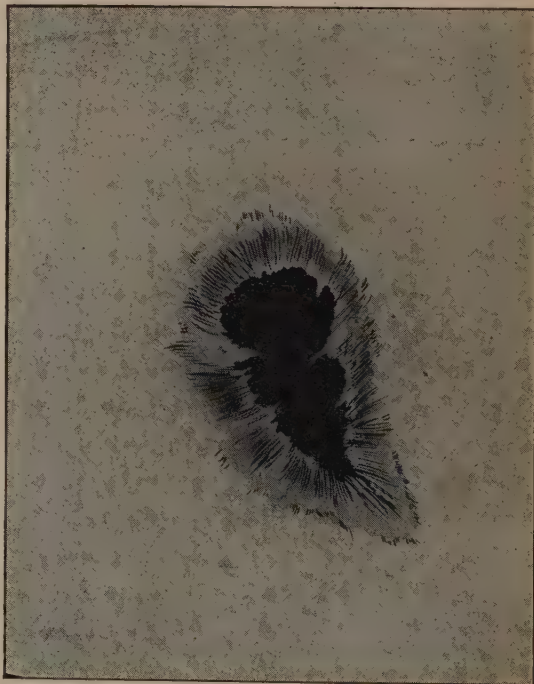
If we look at this group a few weeks later we find that the spots have changed considerably.

Why have the spots changed? The answer is that the sun turns on its axis, just in the same way as the earth does. We know that the earth turns round once in twenty-four hours, and that this turning causes night and day. The sun turns round once in twenty-seven days, and the spots turn with him. They are first seen coming round the right-hand edge of the sun, and each day they move a little farther toward the center, then gradually travel toward the left-hand edge, and at last disappear round it.

When the sun-spots are coming round the edge of the sun we see but part of them. As they get near the sun's center we see them full in the face. Suppose we get a very big ball and fasten a half-dollar piece to it, and get a friend to turn

the ball round. If we stand some distance off, and watch the ball turning, we shall see the coin gradually come into sight, from the back of the ball. First of all we shall see only part of the half-dollar, and it will look almost like a thin line instead of a round coin. Then gradually, as our friend turns the ball, the half-dollar will seem to get more and more circular in shape, until, when it has reached the center of the ball and is opposite to us, it will appear to be quite round. It is exactly the way with the sun-spots.

Now what are sun-spots? The sun is surrounded by a covering of gases, which is called the *photosphere*. This word is made up from two Greek words: *photo* means "light," and *sphere* means "surface," so that the photosphere is the surface which gives forth light. The sun-spots seem to be holes, or rents, in the photosphere of the sun. Look at the next picture and you will notice that it seems as though we are looking right through a great opening in the bright surface of the sun; and this is indeed the case. We do not know what causes the sun-spots, but perhaps the violent storms which are always raging



A SUN-SPOT, APRIL 4, 1909.

on the sun have something to do with these great breaks in the light-giving surface, just as a great wind will often cause a break in the heavy rain-clouds in our sky.

Sometimes there are scarcely any spots on the

sun, but at other times the sun's surface is covered with them. In the same way, the spots are sometimes so small that it is difficult to see them even with a powerful telescope. On other occasions there are spots so large that they can be seen with the naked eye, by using a piece of smoked glass to protect the eyes from the dazzling sunlight. The sun is a long way off, and even what we know must be a very large spot looks small at such a distance.

There is another peculiar fact about sun-spots, and this is that they are more numerous at certain times than at others. Sun-spots are not formed all at once; the astronomer first of all sees that there is something happening in a certain part of the sun's surface, for the little *faculae* are seen all about this particular region. In this locality, perhaps during the course of a few days, a little spot is formed.

Nearly all sun-spots are round at first, but they gradually lose their circular shape and become twisted into all manner of peculiar forms. After

a while—it may be a few days or it may be weeks—the spot seems to begin to break up, and shooting across it may be seen streams of white matter. These gradually cover the spot, and in the course of time it disappears. So the sun goes on, spots breaking out, and then being covered over again. A great deal of time is devoted to the study of the sun, and a marvelous study it is, yet many people never give a thought to the wonderful things which are to be seen on our sun, and the interesting facts to be learned from them.

ECLIPSES

SOMETIMES occurs what is called an eclipse. The word eclipse comes from a Greek word meaning "to fail." When an eclipse occurs the light fails and becomes weak, so you see how the eclipses got their name.

The eclipses we see are either of the sun or of the moon, and are of two kinds—partial eclipses, where only part of the light of the sun or moon is cut off; and total eclipses, where all the light is cut off. Eclipses of the sun take place when the moon comes between the earth and the sun, thus cutting off more or less of the sunlight.

Though we may hope to see many partial eclipses of the sun, it is not often that we can see total eclipses in this country, as they more often are visible only in countries near the equator. A total eclipse is a very beautiful sight, and astronomers willingly travel to far-off parts of the earth in order to see it.

When a total eclipse of the sun takes place, the moon comes exactly between the sun and the earth, cutting off all the sun's light, and the sky is dark. In fact, it is so dark that hens go to roost, and sensitive flowers close their petals, thinking that night has come. The eclipse may last for a few minutes, and after it is over the sun shines once more, the hens wake up, and the flowers open their petals.

Many savages are terribly afraid of a total eclipse of the sun, for they do not understand its true cause. They think that some great monster is coming to swallow up the sun, and they imagine that by making a great noise they will be able



TOTAL ECLIPSE OF THE SUN, MAY 17, 1882.

to frighten him away. When they see a black object creeping over the sun, they beat furiously on their gongs, blow their horns, and add to the general noise by shouting and wailing. When the dark body has passed away from the sun, they imagine that their efforts have been successful and that the monster has been frightened away.

When a total eclipse is about to take place, the first thing that is seen is the dark edge of the moon just touching the sun, and resembling, in this respect, a partial eclipse. Gradually, as the moon travels along, the black part moving across the sun grows bigger and bigger, looking as though some one had bitten a piece out of the sun. This gets larger and larger until at last the moon has entirely covered the sun, and then darkness sets in over the land. Just at this stage a most beautiful sight is seen, for all around the dark body of the moon, which is now covering the sun, is a beautiful halo of soft pearly light, called the *corona*, a Latin word meaning "a crown." This name is very suitable, for the corona forms a very lovely crown to the eclipsed sun.

The corona is always round the sun, but the sunlight is so bright and dazzling that we are not able to see it except during the time of a total eclipse of the sun, when the moon exactly covers the sun, and by cutting off the bright light, renders the corona visible, as shown in the picture.

The earth throws a long shadow behind it into space, just in the same way as a ball will throw a shadow when held in the light of a lamp. The earth's shadow is only visible when it falls upon the bright surface of the moon, thus cutting off the moon's light and causing an eclipse. Eclipses of the moon can only take place when the moon is full, and, like eclipses of the sun, may be either total or partial.

THE PROMINENCES

DURING these eclipses, when the moon is exactly in front of the sun, nearly all the light of the sun is cut off, though a kind of halo of sunlight surrounds the black moon. Little spikes of light seem to be standing out round the edge. These are called prominences, or sun-flames. Although they may not appear to be very large, they really are tremendous in size.

We have mentioned that at the time of a total eclipse of the sun it is almost as dark as night, and indeed if it were not for the corona it would be quite dark.

Stars are in the sky during the daytime as well as at night, but the sun's light is so strong that we cannot see them during the day. However,

when an eclipse of the sun takes place and it is dark, the stars are seen shining in the sky just as though it were night.

As we have said, the sun is a very long way off, and objects look small at such a great distance, even though they are huge. As a matter of fact, our distance from the sun is so great that if we were to lay a railway from the earth to the sun, and start a fast train along the line, it would take it about 275 years to reach the sun, even though it traveled day and night! At such a tremendous distance the prominences look only like small spikes, sticking out from the edge of the sun. Some of these great sun-flames are so huge that, even were we to place thirty worlds as large as our earth, one on top of the other, the prominences would be still higher!

There are all kinds of prominences, both large and small, and of various shapes. Some look like sharp spikes, while others resemble beautiful plumes. Sometimes we may see these objects floating above the edge of the sun, just as the clouds float above the earth. Very often the prominences resemble huge flames which flicker up and down, like the flames of our fires. Formerly the prominences could be seen only at the time of a total eclipse, but two astronomers, Janssen and Lockyer, found that by the aid of a wonderful instrument called the spectroscope they could be seen at any time, even in broad daylight.

This was a great discovery, for up to that time astronomers had known very little about the prominences, because it was only possible to see them for a few seconds during a total eclipse, and they were unable to make many accurate observations. But when the spectroscope allowed the prominences to be observed at any time, it gave astronomers more opportunities to watch these wonderful objects, and it soon became known that the prominences were really great flames of gas, probably caused, to some extent, by the storms which are always raging on the sun. It may be that the same outbursts have a connection with the sun-spots, but this we cannot yet say. When we look at the sun calmly shining over some beautiful landscape, or sinking beneath the horizon amid glorious sunset clouds, we might imagine that of all things it is the most calm and peaceful; yet this is not so, for the sun is a place of furious storms and raging tempests. These storms are not made up of wind and rain, like those of our earth, but are composed of giant flames, each possessing a heat so terrible that it would scorch the earth to a cinder should our planet come into close contact with such a flame. There is no fear of this, however, for the sun is

such a long way off that, although we may feel its heat on a warm summer day, the heat of the prominences themselves is never felt by us.

THE MOON

WE all know how beautiful the moon looks when it is seen as a thin crescent in the western sky, just after sunset. It looks very lovely, too, in the south, when it is "full moon," as we call it. Often it makes the darkest night quite light, and on a moonlight evening people may be heard to say: "What a lovely night; it is almost as light as day!"

A telescope is like a big magnifying-glass; and we know that when we look at a newspaper through a magnifying-glass the print appears much larger. In just the same way when we look at the moon through a telescope we see it larger, and so we can make out features on it which are quite invisible to the naked eye. The sight is very beautiful. All over the moon's surface we see great mountain-ranges, while there are also a great number of volcanoes. It is one of the most beautiful sights imaginable to watch the sunrise on these wonderful mountains; and it is our own sun which lights up the moon, for the moon is another world, something like our earth, though considerably smaller. In one respect, however, the moon differs greatly from the earth. *The moon is a dead world.* Its great seas are now all dried up, and its volcanoes no longer shoot forth fire as we believe they once did, long ago. On the moon there are no towns and cities, no people and children. There are no trees, no flowers, and, worst of all, there is no air.

Astronomers have carefully watched the moon-mountains for many years, but so far they have not found a single mountain to change to any extent. It is just as though the moon had been put under a glass case years and years ago, and had not altered since.

Many people cannot understand how it is that the moon changes shape so often, and why it is sometimes a thin crescent, and at other times a "half" moon or a "full" moon, as the case may be.

If you hold an apple exactly between your eyes and a lighted candle, the light falls on the side of the apple turned away from you, and so the part of the apple toward you is quite dark. If, now, you slowly move the apple to one side, the illuminated part will gradually come into view. The candle represents the sun, and the apple the moon; and the illuminated moon gradually appears in the same way. These changes in the moon's appearance are called the "phases."

We often hear people speak of "the Man in

the Moon," and although we know that this "man" does not really exist, we can almost imagine that the strange, irregularly shaped spots form the outline of grotesque figures.

THE MOON-MOUNTAINS

LONG ago, at some time in the life of the moon, some of its mountain-peaks were great volcanoes shooting forth stones, and probably molten lava, just as Vesuvius, Etna, and other earthly volcanoes do. These great masses of stones and rocks flew up into the air and then fell back to the surface of the moon, forming in this manner rings round the peaks of the volcanoes. They would be shot up in something the same way that the fountains in our parks throw water into the air, and if you are able to see one of these fountains playing, you will notice that the water falls back round the jet of the fountain. It is in this way that we suppose the great masses of stones and other materials fell round the volcano-peaks of the moon, thousands and thousands of years ago.

There are large numbers of these extinct volcanoes on the moon, and they are of all sizes. The surface of the moon looks interesting, in a certain sense; yet it is quite barren and desolate; and there is a death-like stillness over everything, for there is no life upon it. A picture of the moon looks desolate indeed compared with the lovely landscapes of our earth.

The craters of the moon are so numerous that astronomers have had to give each one a name, in order that they may be referred to without any confusion. Some of the craters are called after mountains of the earth, while others are named after famous astronomers. There is, for instance, a long chain of moon-mountains called the Alps, another the Apennines, while there are craters bearing the names Copernicus, Plato, Tycho, and Theophilus. These latter names are those of learned men who lived long ago. Astronomers have devoted a great deal of time to studying the moon, and maps have been made of the objects on its surface. It has been said that we know the moon's surface even more accurately than we know the surface of the earth, because we can never really see the features of the earth, while the details of the moon's surface may be seen any clear night with the aid of a telescope.

When we look through a telescope at the moon, it seems as though we are looking at it from above—in fact, we are getting a bird's-eye view. There are many, strange, dark patches on the

moon, but astronomers have not yet found out their true nature.

To all who have telescopes the moon-mountains are a most interesting study, and many astronomers spend a great deal of time drawing and measuring the craters, while others devote their time to photographing the moon under different aspects.

In many cases we know exactly how high the moon-mountains are. It is interesting to know how astronomers have been able to measure the mountains of another world, which they have never been able to see close at hand. We know that a flagstaff throws a shadow when standing in the sunlight, and a man who is clever at figures could very soon tell you how high the flagstaff was, without bothering to climb to the top and measure it with a tape-measure. He would measure the length of the shadow, and then, by a simple calculation, he would tell you exactly how high the flagstaff was. The moon-mountains throw long shadows too, and astronomers have measured the length of these shadows; and just as the man of figures tells how high the flagstaff is, so too can the astronomer tell us the height of the strange, fantastic mountains of the moon.

MERCURY AND VENUS

We have seen that there are other worlds besides the earth, which travel round the sun and depend upon it for light and heat. These worlds are called planets.

We cannot say whether there are people living upon these other worlds or not, for although our telescopes magnify a great many times, the planets are so far away that even the largest telescopes in the world could not show us living creatures, even if they were there.

Mercury is the smallest planet of the sun's family, and is not often seen, because it keeps close to the sun. It is small and not very bright, and is best seen in the clear air of the country, and then only at certain times of the year. Venus, however, seems to make up for Mercury's lack of brightness, for Venus is the brightest of all the planets. It is a lovely object, looking like a very bright star, outshining all other heavenly bodies except the moon.

Venus is about the same size as the earth, and so Venus and the earth are often referred to as the "sister planets." When Venus happens to be in our evening skies near Christmas-time, numbers of people think that it is the star of Bethlehem; but this is not so, for though no one knows what the star of Bethlehem really was, it certainly

was not Venus. We are told that the star of Bethlehem moved along in front of the wise men of the East, and of course Venus, or any other planet or star, could not move in that manner. Besides being a beautiful object to the naked eye, Venus is also a lovely sight seen through a telescope.

For the reason that Mercury and Venus come in between the earth and the sun, they resemble the moon in the fact that sometimes, seen through a telescope, they appear as thin crescents of bright silvery light, like the moon when it is "new." At other times they resemble "half" moons, or even "full" moons. The cause of these changes is just the same as that of the moon's changing shapes.

Venus is very brilliant, even to the naked eye, and through the telescope it is brighter still. It is supposed that this great brightness is caused by clouds which surround Venus, and reflect the sun's light, just as a looking-glass does. Our clouds reflect the sunlight also, and we often have seen great white masses of cloud, looking like snow-mountains, reflecting so much light that they dazzled our eyes. The thick covering of clouds that surrounds Venus prevents us from seeing any continents or oceans which may be there. It is true that now and then we can see faint shadings, as though the clouds sometimes thinned out a little, and allowed us to peep through and see markings on the planet beneath.

THE EARTH AND THE PLANET MARS

OUTSIDE the path of Venus lies the path of the earth, while beyond that is the path of the planet Mars. We know that the earth travels round the sun, and takes $365\frac{1}{4}$ days to make the journey. As 365 days make a year, each year there is a quarter of a day left over. In four years, therefore, there will be a whole day extra, and as February is the month with the smallest number of days, astronomers put the extra day into the month of February every four years, and that year is called leap-year.

The earth reflects light just as the moon does, and as the other planets do. We can scarcely imagine our fields and seas reflecting back the sun's rays, but if we were to stand on the moon and look toward the earth, we should no doubt see it shining like a great moon in the sky.

Outside the path of the earth are the paths of five other planets, and the nearest of these is the planet Mars. Mars was called by the people of old the "Fiery Planet," because it shines with quite a red glare.

Looking at Mars through a telescope, we find

that it is not so dazzlingly bright as Venus, and we can see markings on its surface. In the picture of Mars you will notice that there are two kinds of markings to be seen, dark and light. It was at one time supposed that the dark markings were seas and the light markings land, but whether this is so or not we cannot tell.

One of the most interesting objects on Mars is the white spot seen at the top of the picture. We know that at the north and the south poles of the earth there are great plains of ice and snow. If we could stand on the moon and look back at the earth, these polar regions would no doubt appear as white spots. When we look at Mars through a telescope we see just such a white spot at the pole, and we believe that this spot is really a great mass of ice and snow. As summer advances on the earth the ice and snow of the polar regions melt, and we sometimes read in the newspapers of great icebergs being seen in the Atlantic Ocean. These icebergs are really portions of the enormous fields of polar ice which have become detached during the melting, and have been carried southward by ocean currents. During the summer of the planet Mars we can see the white cap growing smaller and smaller, and we believe that this is due to the melting of the ice and snow in the same way as on our earth.

This and other things lead us to suppose that Mars is a world something like our own earth. There is, however, one great difference between the two planets, and this is that, whereas the earth has an abundance of clouds, Mars has practically none. Therefore, it must be continually fine weather on Mars, for if there are no clouds there cannot be any rain. Whether people exist there, to enjoy this beautiful state of things, we do not know at present, but some day we may, for astronomers appear to be growing wiser all the time. Mars is such a vast distance from the earth that even our largest telescopes show nothing more than the differently colored markings on the surface of the planet.

Our earth has only one moon, but Mars has two, though both are much smaller than ours.

THE PLANET JUPITER

OUTSIDE the path of Mars lies that of the planet Jupiter, or the "Giant Planet," as it is often

called. Jupiter is the biggest planet of the sun's family, and is more than 1300 times as large as our earth; that is to say, if we had a great pair of scales, and placed Jupiter in one pan, we



MARS.

should have to put 1300 worlds as heavy as our earth into the other pan before we could equal Jupiter in weight. This explains why Jupiter came to be called the "Giant Planet."

Perhaps the most interesting feature about Jupiter is seen in his moons. The earth has only one moon, and Mars two, but Jupiter has eight. It would indeed be a beautiful sight to see eight moons in the sky at one time, but Jupiter is even farther away from us than Mars, and four of his moons are very tiny and difficult to see. The other four, however, are large, and can well be seen with even a small telescope.

Just as the moon travels round the earth, so do Jupiter's moons travel, and through a telescope we can see them slowly moving. It is a most beautiful sight to see this planet and its moons, because it is almost like a model of the sun's family.

You perhaps have read of a famous astronomer named Galileo who lived many years ago in Pisa, the town that is famous for its Leaning Tower. Galileo was one of the first to use a tele-

scope, and one night he directed his instrument to Jupiter. There he saw the wonderful sight of the moons traveling round the great planet, and he called his friends to look with him. But at that time people really thought that the earth was the center of everything; they even believed that the sun traveled round the earth, instead of the earth round the sun. Galileo had tried to show them that the earth was not the center of all things, and that there were other worlds as well as the earth traveling round the sun. The people, however, looked upon him as a magician, and he was cast into prison, undergoing many trials and hardships.

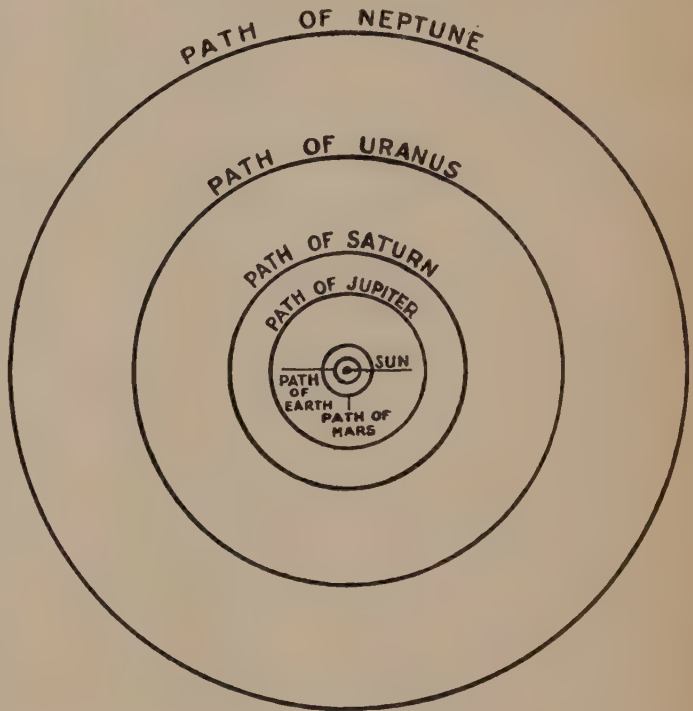
After a time Galileo was allowed to go free, and it was during this part of his lifetime that he applied the telescope to the stars and the planets. When he saw Jupiter, and the moons traveling round it, he again put forward the theory that the earth travels round the sun, and he used Jupiter and its moons as an illustration of how this could be accomplished. At first people would not believe him, and said that there must be something the matter with his telescope, so he asked them to look for themselves. They looked, and were forced to admit that there was a system of moons traveling round the great planet, but they then said that Galileo had bewitched either the telescope or their eyes, thus putting forward every objection they could think of, in order to try and make themselves still believe that the earth was the center of all things. After some time, however, many other learned men took up the subject, and the people had to give in. It was clearly shown that the earth did travel round the sun, and Jupiter and its moons helped to prove it. Therefore, it is very interesting to be able to look through a telescope and see these same moons traveling round Jupiter, exactly as they did in the far-off days of Galileo.

THE CLOUD-BELTS OF JUPITER

THE planet Venus is probably surrounded by a mass of clouds. Jupiter too is surrounded by clouds; but while the clouds of Venus do not show any definite shape or any pronounced markings, the clouds of Jupiter range themselves in great belts across the planet. Very often they

are seen to have peculiar shapes resembling, in some degree, the beautiful "snow-mountain" clouds of our own skies.

Though Jupiter's cloud-belts change their



THE PATHS OF THE PLANETS.

shapes very often, they nearly always lie in straight lines. For the most part they are of beautiful colors, so delicate that only a trained eye can perceive them. They vary from bright yellow, or a reddish brown, to perhaps chocolate color, and sometimes there have been seen faint blue and green clouds too. Very often great white clouds are seen lying near to the delicately colored clouds, and, as you may imagine, many beautiful pictures are formed.

Some years ago, in the center of a curious spoon-shaped marking, a wonderful object was to be seen. It was of a bright red color, and was known as Jupiter's Great Red Spot. During recent years it has faded, and is now only to be occasionally seen as a faint gray marking. The Great Red Spot was first seen in 1878, and it has been one of the most interesting objects to astronomers. What it is, no one can tell, and although many theories have been put forward, none has been generally accepted as satisfactory.

Jupiter is not perfectly round, but bulges out slightly at the equator. We have seen that this planet is a very big world, and that it rotates on

its axis very quickly. The earth turns once in twenty-four hours, but Jupiter turns in a little less than ten hours. As it is a much bigger world than the earth, it has therefore to turn at a very much greater speed, and it is this great rate of turning that makes the planet bulge out at the equator.

Sometimes Jupiter's moons come in between the sun and the planet. If we pass an apple between a lighted lamp and the wall, we find that the apple throws a round black shadow on the wall. In the same manner the little moons, passing between Jupiter and the sun, throw tiny round shadows on the planet.

For many years astronomers have been looking at Jupiter through their telescopes, and they have made careful drawings of the cloud-belts, as well as notes of their color and of the positions of the moons, so that we have come to know a good deal about this interesting planet. Because Jupiter is such a giant among the planets, it is a very suitable object for a small telescope. If you ever have the opportunity of looking through a large telescope, ask the astronomer to show you Jupiter, if it is to be seen, and you will be delighted by watching its four largest moons and by observing the cloud-belts which cross the planet's disk.

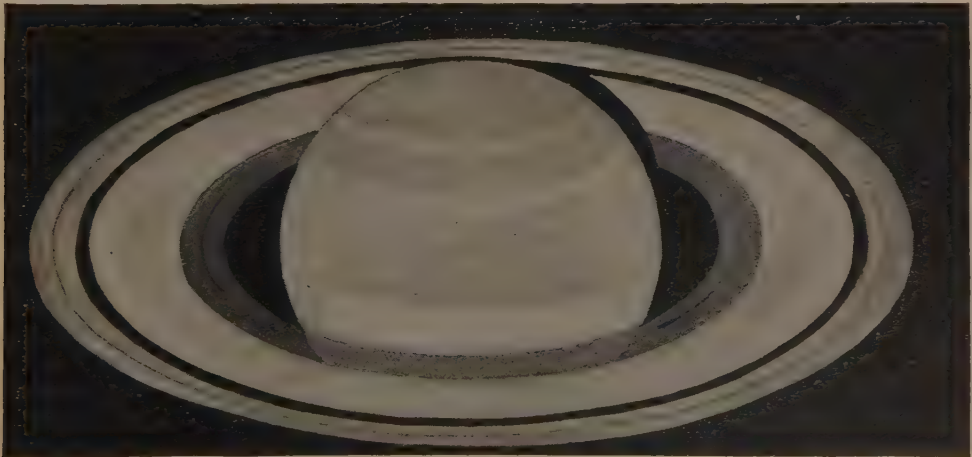
SATURN, THE PLANET WITH THE RINGS

LET us now turn to what is perhaps the most beautiful object that we may ever hope to see in the heavens. This is the planet Saturn, whose path lies beyond that of Jupiter. Saturn differs from all the other planets of the sun's family in that it is encircled by a beautiful series of rings. These

rings can be seen only through a telescope, and although they extend quite around Saturn, we see them sideways and they look something as a plate would look if it were held edgewise.

It was a complete mystery to the people of old how a planet could be surrounded by rings which had no means of support, for they do not touch the planet anywhere. It has lately been shown, however, that Saturn's rings consist of multitudes of little moons, each traveling in its own path round the planet, just as the larger moons of Jupiter travel round it. The moons forming Saturn's rings are so tiny, and so far away from us, that even with our greatest telescopes we cannot see each one separately, but they appear as a beautiful ring of light surrounding the planet. As will be seen from the picture, there are dark rings as well as bright rings, but these dark rings are really blank spaces in the bright rings, where the little moons have been taken away, as it were, thus making a gap in the bright ring. The two brightest rings are called the Outer and the Inner, and you will notice that the Outer ring is not quite so bright as the Inner ring, while a well-marked division separates them. This division is called the Cassini Division, because in 1675 a famous astronomer of that name was the first to notice the division in the rings. If you will look at the space between the Inner bright ring and the planet, you will see there a beautifully fine ring, which is neither bright nor dark. It looks, indeed, as though it were composed of gauze, and for this reason it is known as the Crape Ring. You will notice also that we can see through the Crape Ring, for the edge of the globe of Saturn is clearly visible through it.

At certain periods Saturn tilts himself toward us, and consequently at one time we are looking



SATURN, SHOWING THE RINGS WIDE OPEN.

at the rings almost from above, at another we appear to be looking at them when they have turned a little farther upward, and at still another time we see them exactly edgewise. It is at this period that the rings look like a thin line extending for a short distance on each side of the planet. We can easily see how this extraordinary change takes place by holding a plate at arm's length, and by gradually lowering the front edge until it seems to be only a thin line of porcelain. When the rings are exactly edgewise they are almost invisible; indeed, unless a powerful telescope is used, the rings seem to disappear, which shows that they must be very thin.

When Galileo turned his telescope upon Saturn, three hundred years ago, he was much puzzled by the changes of Saturn's rings which have just been described. His telescope was one of only low power, and it did not show objects sharply and clearly. It was for this reason that he could not see the true nature of the rings, and they were most mystifying to him. Through his telescope Saturn seemed to be composed of three bodies, which appeared to touch one another and to keep in the same positions, being, in fact, almost in a straight line. Of the three bodies, the center one looked the largest, and writing of Saturn, Galileo said: "I have observed with great admiration that Saturn is not a single star, but three together, which, as it were, touch each other . . . the middle being much larger than the lateral ones" (the side ones). He goes on to say that "Saturn has an oblong appearance and is somewhat like an olive." Galileo died without solving the mystery of the rings of Saturn.

It was not until forty years later that another clever astronomer, a follower of Galileo, called Huygens, saw the rings of Saturn in their true form.

Saturn's rings do not shine by means of their own light, but, like the moon and the other planets, they reflect back to us the light of the sun. The globe of Saturn is surrounded by cloud-belts, something like those which encircle Jupiter; but the details of Saturn's clouds are not nearly so distinct, as seen through the telescope, as those of the "Giant Planet," because Saturn is so much farther away than Jupiter.

The farther away from the sun a planet is situated, the longer it takes it to travel round. The earth travels round the sun once a year, and Jupiter, being farther away, takes twelve of our years to go round. Saturn, however, takes a little less than thirty years to complete its big circle round the sun, and long though this period may seem, we shall presently see that there are members of the sun's family that take even longer.

We have read that Jupiter has eight moons, but Saturn has even more, being attended by ten satellites. Just imagine what a grand sight it would be to see ten moons in the evening sky; and if we were able to journey across space to Saturn we should see not only this sight, but probably the lovely rings as well, stretching across the sky, and looking like a beautiful arch of bright light.

If ever you have the chance of looking through a telescope, be sure you make the most of your opportunity and gaze upon Saturn; though you may not be able to see all its moons, you will never forget the sight of the exquisite rings that encircle the loveliest planet of the sun's family.

THE PLANET URANUS

BEYOND the beautiful planet Saturn, there are still two other planets, called Uranus (pronounced "You'ran-us") and Neptune. These two members of the sun's family are so far away that we know very little about them. Even in a large telescope they seem very small indeed; and though it has been supposed that they have cloud-belts, perhaps resembling those of Jupiter, yet we cannot state this with certainty. One of the most interesting things about Uranus is the way in which it was discovered. This planet is so far away that it appears almost invisible to the naked eye; and so in the days of old, before telescopes were invented, Uranus was unknown, as was also Neptune. The people believed that Saturn was the outermost planet of the sun's family, but in this they were mistaken, as we shall see.

One of the greatest astronomers that ever lived was Sir William Herschel; but before he became an astronomer he was a soldier in the Hanoverian Guards. In 1757 a war was going on, and one night, just before a great battle, Herschel and some other soldiers had to sleep as best they could in a wet and muddy ditch. Herschel did not like this, and so he ran away and left the army. Herschel was very fond of music, and he went to England, where he thought he would be safe from capture. He was exceedingly studious, and every minute he could spare he devoted to music. Intending to master his subject thoroughly, he began the study of mathematics. This study deals with measurements of distances, both great and small, and it was in this manner that Herschel was brought into touch with astronomy. Though he had often admired the stars on a clear night, he probably never thought much about them until he came to study mathematics.

Once astronomy had roused his interest,

Herschel saw what a wonderful and splendid science it was, and he began to give much time to the study of the heavens. So interested did he become in his new hobby, that there soon came a time when he liked astronomy even better than music. He began to make telescopes, small ones at first, and then, as he explored the wonders of the heavens, he wanted larger instruments, and these also he set himself to make. Not only were the stars he saw with his naked eye shown more distinctly in his telescopes, but he soon found that there were hundreds of stars to be seen with his instruments which, without them, were quite invisible.

And so the months passed by, Herschel teaching music-pupils in the daytime, conducting concerts at night, and after they were over, sitting up observing the stars with his telescope; or, if the night was cloudy, making bigger instruments. It is said that he would even run out during an interval in a concert in order to do a little more work on the telescope he happened to be making. In this way Herschel began the study of astronomy, little thinking that he was soon to become famous throughout the world. He had one companion in his long night-watches—his devoted sister Caroline, who would sit in the little shed near his telescope and write down the observations he made at the instrument. One hardly knows to which of these two the chief credit is due—to William for his persevering and scientific mind, or to Caroline for her painstaking and accurate notes of her brother's observations.

The time came when Herschel decided to possess a large telescope. As he could not afford to buy one of the size he wanted, the only thing to do was to make one for himself; so he entered upon the great task, and his home was transformed into a workshop. His drawing-room he used as a carpenter's shop, and his best bedroom was furnished with benches, while tools of all descriptions were scattered about. He would rush home after conducting a brilliant concert and begin working at his great telescope without even waiting to take off his lace collar and cuffs, which were then in fashion. After much hard labor the great telescope was finished, and Herschel set himself to observe all stars of a certain degree of brightness. It was while carrying out these observations that he came across what appeared to him a strange object. In a telescope the stars seem to be only points of light, but the planets appear as round globes—in fact, like little worlds. This strange object, which Herschel found on the night of March 13, 1781, did not resemble a star—it looked more like a planet; and after several nights of watching,

the observer found that it had moved among the stars. Not daring to suppose that he had found a new planet, Herschel announced to the world that he had discovered a comet, and he sent his observations to some mathematicians. These men, however, soon made it known far and wide that the object Herschel had discovered was not a comet, but was indeed a new planet.

Then at once Herschel became famous, and King George III. was so pleased with his discovery that he made him Royal Astronomer. This enabled him to leave his music and to give all his attention to astronomy. Afterward he was knighted, and continued his observations up to the time of his death, being always assisted by his faithful sister Caroline. So we see how, from a poor Hanoverian soldier, Herschel gradually became a famous astronomer and at length the discoverer of the planet Uranus.

NEPTUNE, THE FARTHEST PLANET

If Sir William Herschel's discovery of Uranus was wonderful, so too was the finding of Neptune, which is the eighth and outermost planet of the sun's family. Mathematicians had calculated the path of Uranus, and they were able to predict the exact place in the sky where the planet should be, in order that the astronomers might know where to point their telescopes to observe it. However, it was soon found that there was something wrong with the calculations, for the planet Uranus was not always to be found at the exact place predicted. The figures were gone over time after time, and although no mistakes were found, Uranus was not where it should have been according to the mathematicians. Sometimes the planet was a little late in reaching a certain position in the heavens; again, it was ahead of time. This sort of thing went on for a considerable while, until at last two very clever men—an Englishman and a Frenchman—John Couch Adams and Urbain Jean Joseph Leverrier, set themselves to look into the matter.

It was thought that there must be still another planet outside the path of Uranus, and that this other planet was acting like a great magnet upon Uranus, sometimes pulling it back and making it late, and at other times pulling it forward and making it early. The question that the two mathematicians had to answer was: Is there another planet? if so, where is it?

With a planet that is quite well known, calculations with regard to its exact place in the sky are very difficult. But how much more so must be the finding of the position of a planet that has never been seen and about which nothing is

known! This was the task that Adams and Leverrier set themselves to work out, and it was a curious thing that neither of these men knew that the other had undertaken the calculation; but it soon became known that Adams in England and Leverrier in France were both working at the task. More extraordinary still was the fact that both reached almost the same results in their calculations; but it was not until Leverrier came to make his results known to the world that they found that both had been trying to solve the same problem. Adams had the great sum done first, and he sent his answer to Greenwich Observatory, but the Astronomer Royal of that day did not think much about it, for he did not seem to understand what a long time it had taken to work out the calculations. When he received Adams's result, which gave the position in the sky of the supposed new planet, instead of immediately setting his assistants to work to look at the place signified, the Astronomer Royal put the document in a drawer and forgot all about it. Soon after this, however, the French mathematician sent his answer to a German astronomer, Johann Gottfried Galle, at the Berlin Observatory. Now Galle saw that Leverrier's work was worth looking at, so he did not put it away carelessly, but began to observe the stars in that part of the sky where Leverrier had stated the new planet might be found.

On the night of September 23, 1846, Galle found a strange object among the stars, in the same way that Sir William Herschel had discovered the planet Uranus. In a similar manner it was proved, soon afterward, that the object which Galle had found was indeed another planet, and this was called Neptune.

Great was the rejoicing when the discovery of Neptune became known, and of course Leverrier was delighted that his calculations had been correct. But what of Adams's calculations? He had done the work and got the same answer, but had not received any credit for it, because all this time his calculations were lying forgotten in the drawer at Greenwich Observatory. But if the Astronomer Royal had forgotten about Adams's results in the past, the news of Leverrier's triumph roused him, and he suddenly remembered Adams's calculations. Turning to them, the Astronomer Royal soon saw that they were practically the same as Leverrier's; so he hastened to make known to the world that Adams had sent his calculations to him, correctly worked out, some months before Leverrier had worked out his figures. Although at first the French astronomer was not at all pleased with this news, he soon came to see that there really was much

credit due to the English mathematician, and he generously determined to share with him the glory of Neptune's discovery.

This double discovery was a great achievement, and it will long be remembered in the history of astronomy.

COMETS

At some time or other during our lives we may expect to see one of those wondrous objects called comets. The word "comet" comes from a Latin word meaning "a hair," and, when seen at night, a comet certainly does look like very fine silvery hair, hanging against the dark sky. Unfortunately it is but seldom that we are able to see a really large comet, although there are on an average as many as five comets to be observed in a year. These are, for the most part, small ones, and may only be seen through a telescope.



THE MOREHOUSE COMET, NOVEMBER 16, 1908.

There was a most beautiful one, called Donati's Comet, seen in the autumn of 1858. Although this is a long time ago, many can remember that

comet, because it was such a brilliant object in the sky—so bright, indeed, that it frightened hundreds of people. If you read the poems of Oliver Wendell Holmes, you will find that he speaks of

can puzzle astronomers, and baffle all their attempts to find out of what it is made or from whence it came.

A comet may be said to be composed of two parts—the head or nucleus, as it is called, and the tail. The nucleus is really the comet itself, but people who know little about astronomy think that the tail is by far the most important part. This is not so, although it is quite true that a fine tail makes a comet look very imposing in the sky. Just as the tail of a comet may undergo changes, so too the head or nucleus may alter, though not to such a great extent.

We do not know what a comet really is, for there have not been very many bright comets since large telescopes were made. It is only during comparatively recent years that observatories have been built and fitted up with costly instruments. We can hardly expect, therefore, to know very much about comets when there have not been many bright ones to examine with modern instruments. From what has already been learned, however, it seems probable that comets are largely composed of gaseous matter; or, to put it in another way, they may be simply clouds of gas, which in some manner are held together as they travel round the sun. Some



TELESCOPIC VIEW OF THE BROOKS COMET OF 1900.

a comet as "The specter of the skies," and specter, you know, is another name for a ghost. Although the present writer has never seen a ghost, he is told by persons who say they have seen one, that chairs and tables may be seen through a ghost's body! Just in the same manner we can see stars shining through a comet's tail, and this is probably one reason why comets have been called "specters."

Comets travel round the sun in the same way that planets do, and although the path of a comet is not the same shape as the path of a planet, yet comets obey the same laws, and are ruled by the sun. There was a most interesting comet in November, 1908, called the Morehouse Comet, a picture of which is given. It was very faint, being visible only through a telescope, and was chiefly remarkable for its tails, which underwent many changes. A comet's tail looks something like the steam that comes out of the funnel of a locomotive, but we do not know enough about these bodies to be able to say of what they are composed.

On a certain night the Morehouse Comet had one long tail, but later it developed six tails; and on another night, later still, its tails had entirely disappeared! In this mysterious way a comet



GREAT COMET OF 1832.

comets journey round their paths in a few years, like that called Encke's Comet, which takes about four and a half years to go once round the sun. Others take longer—perhaps many thousands of

years, like Donati's Comet, which takes 2400 years to travel once round the sun!

When a comet is first seen through a telescope, it looks like a faint, misty star, or a tiny patch of delicate light, but as it draws nearer to us its brightness increases, until it is seen in all its glory, and may then be a magnificent object in our skies. After that it fades away, until it is once more a misty patch of light, and, getting gradually fainter and fainter, it is lost in the depths of space, and cannot be seen even with the greatest telescopes in the world. There is one thing, however, from which the comet cannot escape, and that is the pen of the mathematician; for although the comet may be invisible for years, the mathematicians can calculate exactly where it is in the depths of space, and they can also tell when it will return.

HALLEY'S COMET

ONE of the most interesting of all the comets is that known as Halley's, and this comet was to be seen in May, 1910. Edmund Halley was a renowned English astronomer, and at one time occupied the position of Royal Astronomer, at Greenwich Observatory. Comets interested him greatly, so he determined to investigate their mysteries. Very little was known at that time (seventeenth century) about these bodies, so that Halley had to find out almost everything for himself.

After working away at the subject for some time, he thought there was a certain comet that seemed to appear once in about every seventy-five years; but at that time it was not even supposed that comets traveled round the sun, and it was, therefore, a very daring thing for Halley to say that this particular comet came back every seventy-five years. He was so certain of the fact, however, that he predicted the comet's return in the year 1758. Unfortunately, before that year came, Halley died; but, true to his prediction, the comet came back, and the astronomers, who had been expecting it, named it Halley's Comet, as a tribute to the work that Halley had done in connection with comets in general, and with this one in particular.

The fact of this comet's returning every seventy-five years proved that comets obey the same laws as the planets, and that they travel, each in its own path, round the sun. As Halley's Comet comes to the sun every seventy-five years, and as the earth is comparatively near to the sun, it follows that the comet will be visible to us every seventy-five years. It is only natural to suppose

that it might have been seen on many occasions—*before* Halley's time, and by looking up records of comets we can trace this particular object for hundreds of years—indeed, up to a time long before the birth of Christ. Some of these records are made on parchment, but those records of the comet which were made before parchment became known are made upon clay tablets, such as have been found in ancient Egypt.

Of all the records, those of the Chinese have been the most useful in tracing Halley's Comet. The Chinese thought that the stars represented countries on the earth, and they imagined also that they could tell what was about to happen to the nations of the world by watching the stars in the sky. Of course, when a strange object like a



BROOKS' COMET OF 1885. (TELESCOPIC VIEW.)

comet appeared among the "kingdoms of the sky," it was a cause of great excitement, for the Chinese people thought it was a sign that an ambassador was about to visit that particular country on earth which corresponded to the stars in the sky through which the comet passed. Comets were therefore looked upon as very important objects by the Chinese, and very careful records were kept, not only of their appearance, but also (what is more important still) of the stars near which the comets passed on their journey through the sky. The Chinese thought that by keeping these accounts they would be able to predict happenings on the earth, little thinking that these very records would be most useful to twentieth-century astronomers in timing the former appearances of Halley's Comet.

At Bayeux, a city in Normandy, there is a most interesting tapestry. This has all sorts of pictures worked upon it, tradition says by Queen

Matilda, wife of William the Conqueror, but it is somewhat doubtful if she really made the tapestry. At any rate, the Bayeux Tapestry has been very useful to historians and to astronomers, for its pictures have shown us how the people of those days used to dress, and have taught us many other things which might otherwise have remained unknown. One of these pictures shows the people watching a comet in the sky. Above the watchers are inscribed the words, "ISTIMIRANT STELLA," meaning, "These (people) wonder at the star." It has been proved that the comet shown in this quaint old record is indeed Halley's Comet, as seen in the year 1066.

OTHER COMETS

THERE are many comets besides Halley's of which we have records, and of which the mathematicians are able to tell us the whereabouts, although we cannot see them in even the largest of our telescopes. So clever are the calculators that they are able to tell us when each comet will appear, and also the exact place to which we must direct our telescopes to discover it. On an average about five comets are seen in a year, but most of them are not visible to the naked eye. To the astronomers, however, all of them are interesting, whether large or small, but people generally think that a comet is not worth looking at unless it is very bright and has a long, fiery tail.

Sometimes comets get lost and do not come back when expected, as, for instance, that called Lexell's Comet, which in 1779 disappeared from our view and has not been seen since. Then, again, comets may appear in quite different forms from those in which they were last seen from the earth. There was a comet in 1826, known as Biela's, because of its discovery by an Austrian soldier, Wilhelm von Biela by name. This comet took a little over six years to traverse its path round the sun, and in 1846 it actually split into two pieces that traveled along together like two friends out for a walk!

The next time they came back, in 1852, they were still separated, but they are now lost; they have never been seen since. Where they have gone no one can say, but these facts go to prove that comets, although governed by the same laws as the planets, are always unreliable, and may do all kinds of unexpected things.

In January, 1910, another famous comet was visible, by some called the "Miners' Comet," while others named it the "Daylight Comet." This was a very beautiful sight. It was a little to the right of the planet Venus, looking like a sheaf of

golden fire, its beautifully curved tail stretching across the eastern sky for a considerable distance, and resembling a golden simitar.

Although mathematicians are able to tell us a great deal about the comets, and when to expect them, they can only give us information about those which have been seen by astronomers. Sometimes appear comets that are quite unknown and unexpected, and these are indeed "surprise comets." The Daylight Comet was one of this class. It was discovered one morning just after sunrise, by some miners in South Africa. The miners telephoned to the nearest observatory, and the astronomers there sent cablegrams all over the world. A few days later it was seen in other countries, first by those who were on the watch for it and knew where to look, and afterward by thousands of other people.

To the unaided eye the tail of the Daylight Comet appeared as a beautiful curve of golden light, but the photographs taken of it showed that it was really fan-shaped. After a few days of brilliance the comet gradually faded away, until it became but a faint speck in the telescope. It had lost its beautiful tail, and was traveling away into space, from which it will never return.

In years gone by people imagined a comet to be a sign that something of an evil nature was about to happen, such as a plague or a famine. One would imagine that in modern times so foolish a superstition would have been given up, but there are still a few people who seem to believe in it, for when the Daylight Comet was visible in our evening skies, some said that it was the cause of the great floods that were taking place in Paris at the time. These people quite forgot that while there were floods in Paris there was also a "water famine" in Egypt, and the comet could hardly be responsible for both, although the Arabs blamed the comet for causing their water-supply to dry up! Still other people thought that the comet was a sign that the world was coming to an end. But instead of a comet being looked upon as an object of fear, we should be only too glad to see these beautiful visitors and try to obtain all the information we can about them.

THE GREEN FLASH AND THE NORTHERN LIGHTS

SOMETIMES, just as the sun is disappearing over the horizon, we can see its tip turn to a beautiful green color. This phenomenon is known as the green flash. No doubt you will be able to view the flash some time when the night is fine enough to allow you to see the sun actually dis-

appear over the horizon. You should choose a spot where the horizon is quite clear of houses or trees, and then watch the sun gradually sinking lower and lower. First the bottom edge of the sun will touch the horizon, and then it will slowly disappear until it is half gone. At this stage you must watch carefully, for steadily the sun gets lower and lower until there is only a tip left. Then, just before it finally disappears, you may perhaps see a little green flame shoot up, and the tip of the sun itself will turn green. We may see it once out of a dozen times, but it is very interesting to watch the sun disappear over the horizon, and to look for the green flash.

You will notice, when the sun is near the horizon, it loses its circular shape and appears oval, like an egg. It also seems a great deal larger than it does when seen high in the sky. This is because of the extra thickness of the atmosphere near the horizon, which acts as a sort of magnifying glass and enlarges the sun when it is low. The moon also may be seen enlarged in the same way, as it rises in the east, when it is full.

Another beautiful sight that may sometimes be seen in the sky is known as the *aurora borealis*, or the northern lights. This sight takes the form of a sort of fiery mist of a golden color, which is seen in the sky toward the north. What the northern lights are we do not know, but they are perhaps due to some electrical influences; it is remarkable, too, that the *aurora borealis* has a connection with the sun-spots. When a great storm takes place on the sun, there are often beautiful displays of the northern lights seen from the earth; but what their connection with the sun-spots really is, astronomers cannot yet tell. During the summer months the northern sky is lighted up nearly every clear night, but this must not be mistaken for the northern lights, for it is the sun-glow. In summer the sun does not dip very far below the northern horizon, and so it throws up a sort of reflection which makes a beautiful primrose-colored glow appear in the north, during the nights of summer. Occasionally this glow is so strong that it makes the sky quite light. Though this spectacle is very beautiful, it must not be confused with the *aurora borealis*, which does not give off any great amount of light, but appears more like arches of fiery mist in the sky.

We have now considered the solar system, and the planets and comets which belong to it. We have also touched upon the meteors and the *aurora borealis*. Now let us consider the stars themselves, which are quite different from the planets and from those lovely wanderers through space that we call comets.

THE STARS

WHEN we go out on a clear night, we can see a great number of stars, shining points of light in the dark sky. Some look quite big and near, while others look very small, or far away.

Long ago, before people lived in towns and cities, there was a race of people called the Chaldeans, of whom we have read in the Bible. These people, for the most part, followed the occupation of shepherds, and they had to sit up all through the night, guarding their flocks. These Chaldean shepherds were no doubt very lonely during the long nights, for they had no lamps to lighten the darkness. There was one thing, however, which the shepherds loved to do, and that was to look at the stars sparkling with great brilliance. They would often imagine to themselves quaint figures, or pictures, among the stars, just as we sometimes imagine we can see faces in the red-hot coals of a fire.

Not only did the shepherds imagine these star-figures, they gave them names, some of which, wonderful to relate, remain to the present day, though hundreds and hundreds of years have passed since the star-figures first received their names. The shepherds did more than merely give names to these star-figures, which we call the constellations; they made up stories or legends about them. Although most of the stories have been forgotten, there still remain one or two which have come down to us with the names of the constellations.

It is interesting to know that the star-figures you are able to see at night are exactly the same as those upon which the Chaldean shepherds gazed while tending their flocks. Although many ages have passed since then, the stars are still in the same positions, and will probably remain as they are for many ages to come. When one has learned the names of the bright stars, and the positions of the constellations, it is surprising to find how interesting it becomes to look up at the sky on a clear night, for the stars seem like friends as we see them twinkling away in the heavens.

When one remembers about the long and cold hours that the astronomer spends observing the planets or the stars, one might be apt to think that he is lonely in the observatory; but such is not the case, for the stars are the friends of the astronomer, and loneliness, cold, and other discomforts are quite forgotten amid the wonders of the heavens. So, too, on a lonely road at night, the stars take the place of the landscape by day, and are the friends of those who know their names.

THE GREAT BEAR

NEARLY all the star-figures have Latin names, and in mentioning each we will first give the Latin name and then the English, for astronomers usually speak of the constellations by their Latin names. The stars rise and set just as the sun does, and they change, too, at different times of the year. The earth travels along its own path, and there are times when some of the stars cannot be seen except as the earth is passing them, as it were. Of course, after these stars have been passed, they remain unseen until the same time of the following year, when the earth has again reached that particular point in its path. So you will see that we have the stars of spring and of summer, of autumn and of winter.

Although most of the constellations are visible only at certain times of each year, some stars are visible all the year round. The reason for this is that they are, as we may say, over the top of the earth; but the other stars, which disappear

perhaps the best known of these is the constellation called Ursa Major, or the Great Bear, shown in the picture. If you will go outdoors some fine, clear night, and look toward the northern sky,



CASSIOPEIA, CEPHEUS, AND THE GUARDS.



THE GREAT BEAR AND THE POLE-STAR.

from our view at certain times, are lower down, as it were, in the sky.

The stars that may be seen all the year round are found in the northern part of the sky, and

you will soon find the seven bright stars which form this group. They are sometimes called King Charles's Wain, or Wagon, because their shape resembles, to a certain extent, the body of a wagon with its shaft. Each star of the constellation is known by a Greek letter, and these you will see close to the stars in the picture. The two stars marked " α " and " β " are called the "Pointers," because they always point to the pole-star.

The pole-star is what we may call the center of the stars of the sky, for all other stars appear to move round it. Those which are near to it make small circles round it, while those that are farther away make bigger circles. If we could journey to the north pole we should see the pole-star exactly overhead, because it is over the north pole. In spring you will find the Great Bear almost above your head, but in summer it will be between the pole-star and the northwest horizon. In autumn it will again be found to have changed its position, and will be found between

the pole-star and the northern horizon, while during the winter months it will be found between the eastern horizon and the pole-star. It is necessary that we should learn well the position of the Great Bear, and also of the pole-star, for these two figures will help us in finding many other constellations. There is an old rhyme that says:

“He who would scan the figured skies,
Its brightest gems to tell,
Must first direct his mind's eye north
And learn the ‘Bear’ stars well.”

The stars of the Great Bear have been known for a long time as a constellation, and they have been found in a catalogue of the stars that was made over two thousand years ago. From this ancient catalogue it has been found possible to work out the position of these stars, and, it is said, the stars of the Great Bear have scarcely altered their places with regard to one another during the ages that have elapsed since the wonderful old catalogue was made.

STARS NEAR THE GREAT BEAR

HAVING found the position of the Great Bear, we may now go on to another group of stars, called Cassiopeia, or the Lady in the Chair. These will be found almost on the opposite side of the pole-

star to the Great Bear, and as shown in the picture they look like a large letter W. They are very easy to find on a clear night, and we shall find them useful later on as guides to other constellations. Between the pole-star and the Great Bear are two small stars, at no great distance from each other, and these are called the “Guards.” The stars all seem to circle round the pole-star, and if we make a diagram like the picture and stick a pin through the pole-star, we shall be able to turn the picture round, and thus gain an idea of how the stars in this part of the sky move.

We find, in observing the stars, that no matter what part of the sky the stars may be in, whether it be during the summer or during the winter, the Guards will always be in a position between the Great Bear and the pole-star. It is for this reason that they are called the Guards, for they seem to guard the pole-star from the Great Bear. The people of old thought that the Great Bear wanted to reach the pole-star, so that he might add it to his stars; but, they said, the gods had put the Guards in between the Great Bear and his prey to prevent him from reaching the pole-star. The Guards, therefore, will be found always on duty, keeping watch between the Great Bear and the pole-star.

We notice that by the side of the second star from the left hand of the Great Bear stars there



PERSEUS, ANDROMEDA, AND PEGASUS.

is a companion or smaller star. Unless we have fairly sharp eyesight we shall not be able to see this little star, but a pair of opera-glasses will show it quite distinctly. It is a most interesting object. The bright star to which it is near is called Mizar; while the small star is known as Alcor. There is a legend that in olden times the Arabs used these two stars as a test for eyesight, and any Arab who could not see Mizar and Alcor distinctly was not allowed to serve as a soldier. Of course telescopes and opera-glasses were unknown in those days, and it must have been quite an easy thing for the keen-sighted Arabs to see these two stars distinctly, so the Arabian army probably had no lack of soldiers, even if the story be true!

One of the things that astronomers have had to find out, was whether Mizar and Alcor are really close companions, or whether they are not near to each other at all, but only appear so from the earth, just as we may see two street-lamps, one behind the other, which seem to be side by side. There are many of these companion-stars, or "double stars" as they are called, and in some cases three or even four stars are close together. It has been found that in some cases these stars are not really near to each other, but are, like the street-lamps, one behind the other. To this class belong Mizar and Alcor, for they are not really close companions. There are numbers of double stars, however, which really are connected with each other, and many of them are of most beautiful colors.

If you will look toward the northeast, in July or August, you will see there a group of stars, which have a shape similar to those shown in the illustration. The pole-star and Cassiopeia will help you to identify the new group, which is called the Great Square of Pegasus. Its shape resembles, to a certain extent, a frying-pan; the four stars of the square forming the "pan" itself, while the three trailing stars make the handle. This constellation of Pegasus was supposed by the people of old to represent a winged horse, but no matter how vivid an imagination we may have, it is impossible for us to find any such resemblance in the star-picture. As you will see, Pegasus is to be found at about the same distance on the other side of Cassiopeia as Cassiopeia is from the pole-star; and the stars of the Great Square are so bright and clear that you will have no difficulty in finding them rising in the east, during the months mentioned. The stars that may be supposed to form the handle of the frying-pan are members of another constellation, called Andromeda, and the three stars which you will see at the end of the handle are the stars of Perseus.

All these groups are shown in the picture, so that you will have no difficulty in knowing exactly where they are.

THE LEGEND OF ANDROMEDA AND PERSEUS

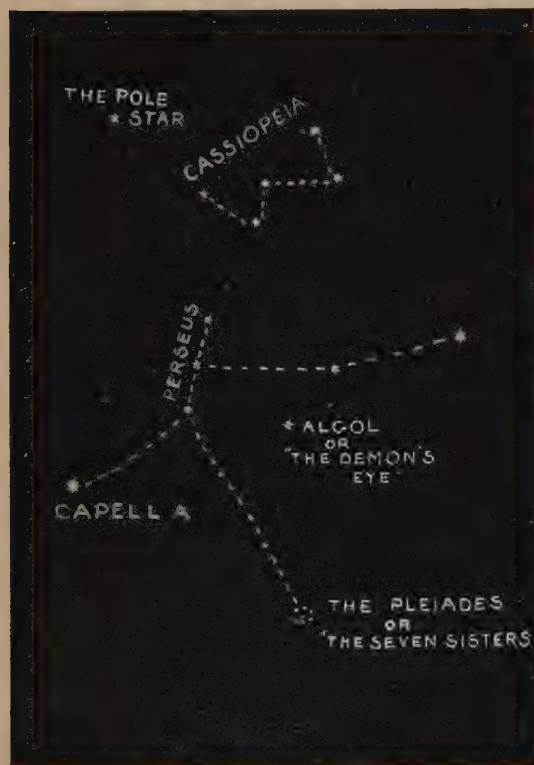
THE constellations of Perseus, Andromeda, and Cassiopeia have each a legend recorded in Greek mythology. The story of Andromeda and Perseus runs as follows:

Once upon a time there lived a certain Ethiopian king, whose name was Cepheus. His wife was called Cassiopeia, and their daughter was remarkable for her great beauty. The daughter's name was Andromeda, and Cassiopeia, her mother, boasted far and wide of her beauty. Now there were a number of nymphs, called the Nereids, who lived in the depths of the Inner Sea, or the Mediterranean, as it is called to-day. Cassiopeia's boastings reached their ears, and they were terribly enraged to hear that any one dared to put in a claim to beauty while they were alive, and they brought the matter to the notice of their father, Nereus. Of course Nereus agreed with his daughters, and he decided to avenge their wrongs by sending a great flood to the country of King Cepheus. The flood came and devastated the king's territory, not only damaging the land and the crops, but bringing with it a frightful sea-monster resembling a dragon. So terrible were these calamities that King Cepheus consulted the oracle of Ammon as to what could be done to get rid of this great flood, and also of the fearful sea-monster, which the people greatly feared.

The oracle declared to Cepheus that the only way to get out of the trouble was to sacrifice the beautiful Andromeda to the sea-monster. In order to save his land and his people, King Cepheus decided to carry out the advice of the oracle, and he ordered that Andromeda should be chained to a rock, there to await the coming of the sea-monster. A strong and noble youth, Perseus by name, happened to be returning victorious from a battle he had just fought with Medusa, and his path lay past the rock to which Andromeda was chained. He saw her, and was so struck by her great beauty that he determined to rescue her and to make her his wife. At this moment, so the story goes, the great sea-monster appeared from the ocean, and, after a severe battle, was slain by the noble Perseus. The conqueror then broke Andromeda's chains and released her, and as a reward for his gallant deed King Cepheus gave him Andromeda for a wife.

Some time afterward one of the Greek goddesses, Athene by name, gave Andromeda and Perseus a place in the skies, where you may see them to this day. Cassiopeia is there too, as we have already seen, and not far away from her is Cepheus.

In the picture you will see some more stars, which are near to Perseus, and which you will



PERSEUS AND THE PLEIADES.

easily be able to find, once you know where Perseus is. The three bright stars of Perseus, just below Cassiopeia in the picture, will enable you to recognize Capella, one of the most beautiful stars that adorn our skies. Capella is situated at the end of a curved line which we can imagine to extend somewhat toward the left from the stars of Perseus. Near Capella are three smaller stars, known as the "Kids," but to see these will require the aid of opera-glasses unless you have sharp eyesight. If we imagine another curve, similar to Capella's curve, but traveling in the opposite direction—that is, to the right instead of to the left—we shall see a little group of stars called the Pleiades, also known as the "Seven Sisters" and sometimes called the "Hen and Chickens." They form one of the most interesting star-groups in

the whole sky. See how many of these stars you are able to count on a clear night. Most people can see six, but those who have exceptionally keen eyesight are able to count nine, or sometimes even twelve.

The Pleiades are not only wonderful for the number of stars which the group contains, but it is a peculiar fact that, though they have been called the Seven Sisters, a person with ordinary eyesight can see only *six* stars in this group. What is more interesting still, perhaps, is the fact that not only is the number of the Pleiades spoken of as seven throughout Europe, but the Indians of North America, the Ashantis of Western Africa, and the Chinese, as well as many other nations, all speak of these stars as being seven, instead of six, the number usually discerned. Each of the nations has various stories telling how the seventh star was lost. These facts show us that there were at one time seven stars visible in the Pleiades, and that one of them has disappeared. Why so many widely separated nations should know of this, when the event must have happened ages ago, is indeed a mystery.

There is another interesting object in the sky not very far from Perseus. This is the wonderful star called Algol, and clearly shown in the picture. The Arabs called Algol "the Demon's Eye," for it shines very brightly for a number of days, then suddenly fades away, and almost seems to "go out." These changes in the brightness of Algol do not take place at all times, or every now and then, but are so regular that they can be predicted by astronomers years beforehand. Every two or three days these changes take place, and during the space of three or four hours the star will fade away or become brighter, as the case may be. The alternate fading and brightening up of Algol was what made the Arabs call it the Demon's Eye, for they thought, no doubt, that it was the eye of some great god slowly winking at them!

There are many of these "winking" stars, or variable stars, as they are called, but Algol is by far the easiest to observe, some of the others taking months, perhaps, to fade away, and then to such a slight extent that the change is only perceptible to the trained eye of an experienced observer.

THE CONSTELLATION OF ORION

Of all the star-figures, perhaps the most interesting and beautiful is that called Orion, the Huntsman. This is the largest of all the constellations, and can only be seen during the months of late autumn, winter, and of early spring. If we look

toward the south on a clear winter night, we may see Orion, made up of stars as shown in the next illustration. Of course we know which is south, for the pole-star is always due north, and south must therefore be in the opposite direction to the pole-star. The word Orion is a Greek name, but long ago the English people used to call him "Orwandle," and also "Grow's Husband." The brightest star of the constellation they called "Orwandle's Toe," but it is now known as Rigel.

If we look carefully at the stars forming this constellation, we can make out the shape of a man marked by the stars. The two bright stars at the top show the place of Orion's shoulders, while two other stars, lower down, mark his knees. Three smaller stars in a line mark the place of his belt, below which are some more stars representing the jeweled handle of his hunting-knife. Orion is swinging high a great club in his right hand, while with his left he holds up a shield. Of the star-pictures, Orion is one in which we can imagine the figure of what it was intended to represent when the people of long ago gave it the name. Orion was supposed to be a mighty hunter, but he did some wicked deed, and the gods put him in the sky to be a warning to men for all time. They also put his two dogs near him, and if you look a little to the left, and lower down than Orion, you will see the Big Dog, or Canis Major, as it is called by astronomers. Sirius, the brightest star in the whole of our skies, is to be seen in this constellation, and because it is the chief star in the Big Dog it is often referred to as the "dog-star."

Near by, but higher up, is Canis Minor, or the Little Dog; while the chief star in this group, though not so bright as Sirius, is a beautiful object, and is called Procyon. There is another star-picture besides the dogs connected with Orion, and this is Taurus, the Bull, and it is this animal that Orion is supposed to be hunting through the heavens. There is not the full figure of a Bull in the sky, but only its head; it is charging down on Orion, and he is holding out his shield with his left hand to protect himself, while with his right he is about to use his great club upon the head of the oncoming Bull. Higher up than the Little Dog we can see two bright stars known to astronomers as Gemini, the Twins, but called by some the "Giant's Eyes."

Ages ago, so the story goes, lived a giant called Daze, and he was so clever that he was able to assume the shape of any bird or beast that he wished. He generally took the shape of an eagle, however, and in this guise he would fly about the land, seeing what he could pick up from men. On one of his journeys he came

across three gods encamped under a tree. They had just killed an ox, and had lighted a huge fire with which they intended to cook it, for they were hungry with traveling far.



THE TWINS, ORION, THE BULL, AND THE TWO DOGS.

Giant Daze, in the form of an eagle, perched himself on a tree, and as he was well versed in witchcraft, he cast a spell over the pot, commanding that the meat should not be cooked until he pleased. The gods built up the fire, which burned brightly beneath the pot, and the water soon began to boil. The meat, however, would not cook, and the gods began to get angry. The more wood they piled upon the fire, the hotter did it become, but still the meat would not cook. As the gods were by this time exceedingly hungry, they began to think that they were never going to get their meal, when Giant Daze cried out from the tree above: "What will you give me if I make the meat cook?" "We will give you a share of the meat," answered the gods. With that the pot began to bubble and boil as it had never done before, and ere long the meat was cooked to a nicety.

One of the gods, known by the name of Loke, took off the lid and was about to lift out the

meat, when Giant Daze swooped down from the tree and caught up the best part of the meat in his claws, leaving only the bones for the hungry gods to pick. Upon this Loke jumped up, and catching up a pole which lay near at hand, dealt Daze a great blow. Daze, however, was ready for this, and he cast a spell upon the pole so that it stuck fast to his back, and Loke's hands stuck fast to the pole! Away flew Daze, with the meat in his claws, and with Loke hanging on to the pole; but the weight of both was so great that the giant could only fly near to the ground. In consequence of this, Loke's feet were bumped against the rocks and stones, while his body was badly scratched by thorns and bushes. Daze then made Loke promise to bring him the Apples of Youth, and on his consenting to do this, released him from his hold on the pole.

After many adventures, Loke managed to bring Daze the apples which he wanted to insure ever-

on the city walls, watching the race, and seeing that Loke was being closely pursued by Daze, they obtained a great quantity of dry shavings and set them along the top of the wall. As soon as Loke, with the Apples of Youth in his grasp, had flown over the wall, the gods set fire to the shavings, and Daze, being so close behind, and flying so fast, could not stop himself, but flew right into the center of the blaze. The flames burned all his feathers, down he fell to the ground, and there the gods slew him. The chief of the gods, however, put the giant's eyes into the sky, and they may be seen there to this day, being now called the Twins.

OTHER CONSTELLATIONS

WE recall the two stars in the constellation of the Great Bear that are called the Pointers, for the reason that they always point to the pole-star. If we imagine a line through the Pointers, but in the opposite direction to the pole-star, during the months of winter, spring, and summer, we shall see the constellation of Leo, or the Lion, as shown in the accompanying picture. In this star-picture one can easily imagine a lion in a crouching position. Six stars form the Lion's head and chest, and these resemble a question-mark which has been turned from left to right, thus: ζ The bottom star, called Regulus, marks the place of one of the lion's paws. Sometimes these six stars are called the "Sickle," for they resemble the sickle of a reaper. Shooting stars appear to come from the "Sickle," on or about November 13 each year, and if you watch this part of the sky late at night on the date mentioned you will be almost cer-



BERENICE'S HAIR AND THE LION.

lasting youth, but the gods were so angry with Loke for having stolen the Apples of Youth, that they bade him get them back from Daze, and even threatened to kill him should he fail to do so. So Loke impersonated a bird and flew away to Giant Daze's house. The giant was out fishing, and Loke, seeing the Apples of Youth upon a table, caught them up and flew homeward with them. Shortly after his departure, however, Daze returned, and finding the apples gone, he changed into his eagle's shape and flew after Loke at top speed. Having more powerful wings than Loke, the giant overtook him, just as he drew near to the gods' city. All the gods were

tain to see a few of these shooting stars, which are called Leonids, because they seem to come from that part of the sky where Leo is situated.

Away to the left of Leo are several smaller stars close together, and these are called Coma Berenices, or the Hair of Berenice. It is said that Berenice, the wife of one of the kings of Egypt, was a very beautiful woman, and her hair was known over the wide world for its loveliness. She offered to give it to the goddess Venus, if her husband should be victorious over the enemies against whom he was about to fight. The King went away to the wars, and by the aid of Venus he conquered all his foes. On his return,

however, he was grieved to find that Queen Berenice had given her hair to Venus, as she had promised, and that this was the price of his victories. The priests and the astronomers were sent for, and to comfort him they told him that they would place Berenice's Hair among the stars, which they did. Between the Hair of Berenice and the Great Bear there are a few faint stars to be seen, which go by the name of Canes Venatici, or the Hunting Dogs. These we will consider in a later division, headed "The Nebulæ," for in this region of the sky there is a most beautiful object called the spiral nebula.

If we again use the stars of the Great Bear as a guide, we can find a beautiful star called Arc-

figure does indeed look like a beautiful crown of sparkling diamonds. Still farther to the east is the constellation of Hercules, and you will thus see that the Crown lies between Hercules and Boötes. In Hercules there is situated the Great Star-Cluster, as it is called, where many thousands of stars seem to be gathered together.

If we look at the picture we see there not only the constellations just learned, but other interesting star-figures. Boötes, the Crown, and Hercules are there, and to the left of this last constellation appears Cygnus, or the Swan; this figure is sometimes called the Northern Cross, because it somewhat resembles a cross in shape. The chief constellation in the southern hemi-

sphere is the Southern Cross, and you will often hear travelers speak of this well-known star-figure. The Southern Cross, however, is not nearly so much like a cross as what we call the Northern Cross, or, to give it its Latin name, Cygnus.

Between the Great Bear and the pole-star we see a long, straggling figure, Draco, the Dragon. This is the great sea-monster referred to in the legend of Andromeda and Perseus, which has already been told. There is also shown on the same diagram Cepheus, the King, of whom we read in the same story. Near the pole-star are a few faint stars, to be seen on a clear night, and these have been given the name of Ursa Minor,

or the Little Bear. Between Cygnus and Hercules is the constellation of Lyra, the Harp, and this is marked by the lovely steel-blue star Vega, which, with Arcturus near by, forms a most beautiful spectacle. To the south of Cygnus is the star-figure called Aquila, or the Eagle, and this is made conspicuous by three stars, the middle one of which is more brilliant than the side ones, and yet not so bright as Vega.

We have now seen something of the constellations, and the pictures which the people of old thought they could see in the sky. Although many of the star-figures do not bear much resemblance to the shapes they are supposed to represent, we are able by their help to learn the constellations, and to name the brightest stars. You will be surprised to find how interesting it becomes to be able to point to a bright star and to name it, or to tell to which constellation it belongs.



BOÖTES, THE CROWN, AND HERCULES.

Arcturus, which is in a line with the last two stars of the Great Bear's seven. Arcturus is of a decidedly golden color, and is one of the most beautiful stars in the sky. Above Arcturus are to be seen five stars, looking somewhat like a kite, with Arcturus for the tail. These form the constellation of Boötes, which is a Greek word meaning ox-driver. Boötes was robbed of all his goods by his brother, so the story goes, and after many hardships and wanderings he invented a plow, which was drawn by two oxen. With this he tilled the land, and made his living by following the occupation of a farmer. His mother was so pleased with him for inventing this plow, and for working the land, that she placed him in the sky, together with the plow; and when you look on the stars of Boötes in the heavens you may see the Plow near by. To the east of Boötes is to be seen a semicircle of seven stars called Corona Borealis, or the Northern Crown; and this star-



THE SWAN, THE DRAGON, AND THE LITTLE BEAR.

WHAT ARE THE STARS?

If we could take a long journey into space, upon a voyage that lasted thousands of years, and if we looked back at our sun, as we traveled, we should see it gradually growing smaller and smaller, until there would come a time when it looked only like a bright star. If we journeyed still farther, we should see it grow fainter and fainter, and at last it would disappear altogether from our sight. All the stars are great suns, just like our sun, and it is because they are so far away that they look like tiny points of light, just as our sun would look at the same distance. Perhaps these stars have planets revolving round them, just as our sun has. How grand it is to look up at the stars, remembering that each one is a great sun, and some of them, perhaps, many times larger than our sun.

One wonders how many stars there are in the sky, for on a clear night we can see what appear to be thousands upon thousands of twinkling points of light. In reality, however, no person can see more than about 3000 stars at one time with the naked eye. But of course 3000 is not the total number of the stars, for if we look through even a very small telescope, the number is increased many times, while through a large instrument they are quite uncountable. The latest photographs, taken with a moderate-sized telescope, show so many stars that it is impossible to count them, and we have to resort to estimates. These estimates have been very carefully made, and it has been found that there must be over one hundred millions of stars visible through a large telescope. We can, perhaps, gain some slight

idea of this tremendous number when we remember that it would take a man a fortnight, without stopping day or night for either rest or food, to count one million.

We have mentioned the Great Star-Cluster in Hercules, and this is shown in the accompanying picture, made from a photograph. It seems as though great numbers of stars had gathered together at this spot, forming a universe of their own. There are more than 3000 stars in this cluster alone, which is about the number that can be seen by the naked eye, in the whole sky, on a clear night. The Hercules star-cluster is not the only one in the heavens;

there are many other such clusters, and one near the Lion, called the Beehive, is so thick with stars as to remind one of bees swarming round a hive, and hence its name.

For the most part all the star-clusters are invisible to the naked eye, but on a very clear night the Cluster of Hercules can just be seen, looking like a faint misty speck.

Not only do the stars differ in brightness, but they also differ in color. Look, for instance, at Vega, which is of a decided blue color, and compare it with the golden-yellow star Arcturus, not far away. Sirius is blue-white, and Capella almost pure white, but Aldebaran, chief of the constellation of the Bull, is of a decidedly red color. We have heard that the stars are suns, some of them more beautiful and many times greater than our sun, and it is supposed that the older a sun gets, the redder it becomes in color. When new, the electric arc-lights in the principal streets of our cities burn with a blue-white light, but as they are used night after night, their light changes first to yellow-white, then to yellow, and finally, when they are almost burned out, their light is of a red color. It is the same way with the stars, for when the star is "young" it is blue-white; as it grows older it changes to yellow, and when almost burned out it assumes a red color. When an astronomer wishes to gain some idea of the age of a star, he looks at its color. By this means he can roughly ascertain its age as a sun; but the age of a star cannot be measured in years, for many millions of years may pass away before the slightest change takes place in a star's color.

The planets, as we know, are worlds belonging to the sun's family. There is a wide differ-

ence between a planet and a star, although they may sometimes look like each other in the sky. A planet is a world circling round a central sun, but a star is itself a sun. One may distinguish the difference between a planet and a star by the fact that a star is always twinkling, while a planet seldom twinkles except when very low down and near the horizon. The name planet, which means "a wanderer," was given to these bodies because they wander, or move, about the sky. In just the same way as the moon appears to travel through the constellations do the planets move among the stars. If we watch a planet for a few weeks we see that it slowly shifts its position with regard to the neighboring stars; and this is another way in which we can distinguish a planet from a star, for the stars do not move among themselves, but are fixed in the sky, as it were; only the planets, or "wanderers," move.

THE NEBULÆ

NEXT, let us consider the nebulae, a class of objects which are most beautiful and wonderful. Nebula is a Latin word meaning "a mist," and the name is really most suitable, because the nebulae look like clouds of fiery mist. There are many thousands of these wonderful objects scattered about the sky, but unfortunately they cannot be seen in all their beauty without the aid of a telescope. We may be able to see one or two of them on a very clear night, looking like tiny, fleecy specks against the dark background of the sky. The nebulae have been called the "Workshops of the Creator." We know that everything has to have a beginning, and that the material from which things are made is often totally unlike the finished object. For instance, there is not the least resemblance between a great mass of steel and the railway engine into which it is made. Neither have the world and the planets always been as they are at the present time; they have been gradually formed—evolved, as we say—from rough material of quite a different appearance. We believe that the nebulae we see in the heavens are the beginnings of countless suns and planets. How grand it is to be able to look at these wonderful objects, and to think that we

are looking right into the "Workshops of the Creator," and seeing in the process of formation suns like our sun, which will, perhaps, in the course of time, have planets circling round them, as our sun has at the present time. The stars are a long way off, but we believe the nebulae are even farther away than most of the stars. Were we to attempt to tell in miles the distance of even the nearest star, we could not give any idea of the vast gulf of space that separates it from us, for the distance is so great that figures would have no meaning.



A STAR-CLUSTER IN HERCULES.

Perhaps, in another way, we may be able to form an idea of the distance of the nearest star. We know that when a cannon is fired, say, a mile away, we first see the flash, and a short time afterward we hear the "bang!" Now, the reason we do not see the flash and hear the report at the same time, is that sound travels much slower than light. It is the same with thunder and lightning, for although the roar of the thunder takes place at exactly the same time as the flash of the lightning, yet we see the flash some seconds before the noise of the thunder reaches us, for

the reason that sound takes time to travel. Sound travels at the rate of about 1000 feet a second, but light, which is infinitely swifter, travels about 186,000 *miles* every second. At this rate, light from the moon would reach the earth in a second and a quarter, and from the sun in eight minutes, but to reach us from the nearest star light takes over four years and four months.

Many stars are much farther away than this, and their distances are so great that astronomers do not speak of them in miles, but refer to them as "light-years," saying, for instance, in the case of the nearest star: "It is over four light-years away from us." Sirius is over $8\frac{1}{2}$ light-years away, while Vega, that beautiful blue star near Cygnus, is at a distance of 27 light-years. The distances of other stars are: Aldebaran, the chief star of the Bull, 32 light-years; Capella, near Perseus, 32 light-years also; the pole-star, 47 light-years; and Arcturus, 160 light-years. It is interesting to remember, when looking at these stars, that we are not seeing them as they are now, but as they were many years ago. For instance, suppose that Arcturus were to be extinguished to-day, it would still continue to shine in our skies, with undimmed brilliance, for another 160 years.

There are about 20,000 nebulae in the heavens, but they are for the most part small, and only visible with powerful telescopes. By far the best known of them all is the Great Nebula in Orion, which is situated in the sword-handle under Orion's belt. With a good pair of field-glasses you will be able to see that one of the stars which form the sword-handle is surrounded by what looks like a patch of misty light, which is really the Great Nebula; and in large telescopes it is a most beautiful object.

We have already made mention of the spiral nebula, situated in the northern constellation of Canes Venatici, the Hunting Dogs. This nebula seems to be whirling round, like the whirlpools one sees in a river; we cannot actually see the spiral nebula moving round, for its distance from us is too great. If we are at the seaside and looking out to sea, we may notice a large steamer far away, perhaps nearly on the horizon. If we look again in a few minutes' time, the steamer will still seem to be in the same place, not appearing to have moved at all, though we know it may be traveling through the ocean at the rate of many miles an hour. Because we are so far away from the boat, it does not seem to move in so short a time as a few minutes, and it is the same with the nebulae, for a man's lifetime is just like a glance at the steamer. We may look at a nebula when we are quite young, and again when we are old,

after the passing of many years, yet the nebula may still appear the same, and may not seem to have moved, although it is probably whirling round at great speed.

THE MILKY WAY

ON a fine clear night, a band of misty light may be seen stretching across the sky, and this is called the Milky Way; sometimes known as the "Fairies' Path." This Milky Way stretches in a narrow band right across the heavens, and one of the best parts in which it may be seen is near the constellation of Cygnus, the Swan. Although the Milky Way only appears to the naked eye as a faint band of light, there is quite a revelation when we turn a powerful telescope to it. No longer is it faint and misty; we find that it is composed of countless numbers of small stars, so far away that the eye cannot see them separately. Only their combined light reaches the earth, and, to the naked eye, looks like a faint band across the sky. Countless numbers of stars are seen, some divided from each other by dark spaces, others heaped up one on top of the other, as it were, so that we cannot separate them. It is indeed a sight which we are unable to understand, and it is all the more wonderful when we remember that each of these tiny stars is a sun, some of them, perhaps, many times greater and more powerful than our sun.

Not the least wonderful things about the Milky Way are the great dark spaces, where it seems as though some one might have been with a spade and shoveled the stars to one side, in the same way that men shovel the snow from our streets. There are many dark rifts in the Milky Way, and some familiar ones are to be found in the constellation of Cygnus, the Swan. These have been called the "Northern Coal Sacks," for they are as black as sacks of coal.

It has been said that our sun really belongs to the Milky Way, and that the Milky Way, and all the stars we know, make up one great star-cluster, but of this we cannot speak with certainty.

One of the most wonderful things that we know about the stars has recently been discovered, and this is that most of the stars are moving slowly through the heavens. They are traveling stars, as we might say, and our sun is one of this class, although we on the earth are unable to feel its motion day by day. The sun, with all the planets, comets, and meteors, is traveling toward a part of the sky which is not very far distant from the beautiful star Vega, in the constellation of Lyra, the Harp. Other stars are

moving also, but not all toward Vega, like the sun, nor are they all moving at the same rate of speed. The sun and planets are traveling toward Vega at a rate which is greater even than the swiftest rifle-bullet, for every half-hour sees us about 10,000 miles nearer that part of the heavens. But the star with the swiftest movement of all is that called by astronomers "1830 Groombridge," because this is its number in a catalogue of the stars made by an astronomer of that name. Some people know it as the "Runaway Star," for it is estimated to be traveling at no less a speed than 138 miles per second. Let us imagine, if we can, this terrific rate of motion! We consider an express train which travels sixty miles an hour to be going at tremendous speed, but the "Runaway Star" travels in one second more than twice as far as the express train does in one hour!

It is interesting to know how astronomers have discovered that the sun is moving toward Vega. As we walk along a street at night-time, we have noticed that the lamps in front of us seem to open out as we travel along. If we look behind, we will find that the lamps at the back of us seem to be closing in as we leave them. Now, astronomers found that the stars in a certain part of the sky, not very far distant from Vega, were opening out, and when they came to think the matter over, they decided to look behind, as it were, at the stars in the opposite part of the heavens, just as we might look behind at the lamps as we walk down the street. As the astronomers looked, and made their observations, they found that it was as they had supposed, for the stars in that part of the sky were actually closing in! Here was a great discovery, for these observations undoubtedly showed that the sun and the solar system, of which the earth is, of course, a member, are traveling toward Vega. What new stars will be seen, as the earth journeys through space, we cannot say, but many ages must pass before even a slight change takes place in the position of the stars in our skies.

Not only has this fact of the motions of the stars been found out, but it has recently been discovered that the stars are not moving this way and that, or indiscriminately, as we should say. They are traveling in streams, just as certain kinds of birds fly away from the north to warmer countries when the cold weather comes. Such birds we call "migrating birds." As many of the stars seem to be traveling in the same direction, in something the same way as the birds, they have been called "migrating stars." For instance, five of the stars of the Great Bear are traveling along in apparently the same direction, and it has just

been discovered that Sirius, the Dog Star, is also moving in the same direction as they are. The Pleiades are another instance of this, for nearly all the stars in this beautiful group are traveling in the same direction, and with a large telescope there are something like 1500 stars to be seen in this particular cluster. The Pleiades, however, are not traveling toward the same part of the sky as are the five stars of the Great Bear and Sirius; nor are these stars traveling toward Vega, in the direction in which our star—the sun—seems to be moving. There may be, and probably are, many other "flocks" of stars traveling in other directions, but as the discovery of the Migrating Stars has only been made quite recently, it is impossible for us to say at the present time. Astronomers are carefully going into the question, and we may hope for some further information on this interesting subject in the course of a short time.

PHOTOGRAPHING THE STARS

THAT wonderful instrument the camera is a very valuable aid to the astronomer. We know that in an ordinary camera there is a lens, which may be called the "eye" of the camera, for it is through this opening that the camera is able to "see" the picture which it is required to register on the photographic plate. The size of the photograph depends, for one thing, on the size of the camera lens, and the larger the lens, the more light it passes through to the sensitive plate behind it. Now a telescope is really a very big lens, and if we place a photographic plate behind the telescope lens, we should be able to take a picture of a star, or whatever we wish. This is the way in which photographs of celestial objects are obtained.

Before ordinary photography was thought of, astronomers had to make all their pictures by drawings, using the pen or pencil, as the case might be. We know how easy it is to make a mistake when drawing a picture, and it is easier still when drawing such a delicate object as some part of the moon. Now that we can photograph these objects, we may be sure of obtaining a perfectly correct picture, which can be obtained a great deal quicker than by the old method.

A certain French astronomer made a beautiful drawing of the moon which took him about twenty years to finish. Nowadays we can get a similar picture by exposing a photographic plate in the telescope, in about three seconds; so you will see that the introduction of photography to astronomy means greater accuracy and a great saving of time.

Perhaps the most marvelous thing of all about

the photographic plate is that it is able to "see" objects which are invisible to the human eye, even though assisted by the largest of the world's telescopes. For instance, Jupiter's eighth satellite is so tiny, and so far away, that no one has ever yet seen it, yet we know it is there, because it has been photographed many times. When we look at the nebulae through a telescope, they seem like faint patches of misty light, but photographs show them to be great bodies of fiery gas, with all manner of peculiar whirlings; parts quite invisible to us are clearly shown on the photographs. The reason why the photographic plate is so much better in this respect than the human eye is because the eye gets only a glance at an object, and very soon becomes tired with the strain of looking. The photographic plate, however, can never get tired, no matter how long it is exposed on an object, so we are able to direct a plate to a nebula for perhaps six or eight hours, or even longer. During the whole time of the exposure, the rays of light from the nebula have been falling on the sensitive plate, and so in the finished photograph, instead of just a glance, we get a sort of condensed view of the nebula. We thus see that photography has been of the greatest service to the astronomer, since by its aid he has been able to find out things which were previously unknown.

There is one difficulty that has to be overcome, however, before the astronomer can take photographs of the stars or the nebulae, and this is caused by the earth turning on its axis. We know that the sun seems to rise and to set, and it is just the same with the stars, for they rise and set too. We can prove this by going out of doors some clear evening as soon as it is dark. We note the position of some bright star, say Vega or Sirius, in connection with some object in the landscape, such as a chimney or a church steeple. Then we go out again in a couple of hours' time, and find that the star has moved considerably in the sky. If we were to take a picture of the stars with an ordinary camera, we would not get a photograph of round dots; we would find on the plate many long lines, for the stars would have moved across the sky during the exposure. Therefore, when the astronomer wants to make a long exposure of the stars, which he wishes to show as round dots, he has to fit some mechanism to the telescope, to turn it in the same direction as that in which the stars are moving, and by this means the rotation of the earth, and the consequent moving of the stars through the sky, is overcome. All large telescopes are fitted with a clockwork device which turns the instrument for the purpose mentioned.

THE OBSERVATORY AND ITS INSTRUMENTS

ONE of the chief things that an observatory is built for is to provide a house for the telescope, and of course all astronomical observatories have their telescopes, which differ in size and make. When telescopes were first invented, some three hundred years ago, their users were very much puzzled as to how they should house them, for the telescopes in those days were of very great length. The old astronomers racked their brains over the matter, and at last decided upon a very simple plan: they left the telescopes out in the open air; without any covering at all! The consequence was that the instruments soon became covered with dirt and dust; they also became very badly rusted. As time went on, and telescopes became more numerous, a method of protecting the great instruments from the weather had to be found, and so to-day observatories are generally provided with a dome which serves as a covering for the telescope. The object of this dome is to enable the instrument to be pointed to any part of the sky, either high or low, according to the position of the object which is being observed. If an ordinary roof had been placed on the observatory, the astronomer would have had to lift off the whole roof every time he wanted to observe, and this would have entailed a loss of time as well as a great deal of trouble. The difficulty is overcome by having a circular-shaped roof, made of metal, which revolves on wheels. In the side of the dome, at a certain point, a long slit is made, extending from the bottom to the top. This is covered with a sliding panel of metal, so that all the astronomer has to do is to open the slit by pulling the sliding panel to one side, and then he can easily turn the slit to any part of the sky he wishes, by revolving the dome on its wheels. The telescope is then pointed through the slit and all is ready for observing.

A story is told of a young lady who, after having been shown round an observatory, said to the astronomer, "I can quite understand how you discover what the stars are made of, but I cannot, for the life of me, imagine how you find out their names!" Astronomers can at least give names to the stars, and all the bright stars have names of their own, or else they are known by a letter of the Greek alphabet.

The smaller stars have no names, but are generally referred to by a number, which is taken from a catalogue of stars. There is still another way of identifying the stars. We know that if a captain of a ship meets with a dangerous or unknown rock, he will enter in his log-book the

latitude and longitude of the dangerous object, and in this way he will be able to warn the captains of other ships of the whereabouts of the danger. In something the same way as the earth is divided up into latitude and longitude, so is the sky mapped out. The celestial measurements are called right ascension and declination, and if an astronomer knows these two quantities of a star, he will have no difficulty in finding any star he wants to observe. But it is most important that the astronomer should have the correct time, in order to find a given object. All large observatories have, therefore, a very good time-keeper, called the sidereal clock, which is very delicately regulated and is proof against all changes of the weather. These clocks are nearly always of beautiful workmanship, and on this account they are very expensive.

In every observatory there is a sort of square-shaped object on the roof. This is the roof of the transit-room, and here is situated a small telescope which is so fixed that it points due south; that is to say, although one may move the telescope up and down, it cannot be moved to left and right, for it is set pointing toward what astronomers term the "Meridian," or the true north and south line in the sky. In the eyepiece of this transit-instrument are some very fine lines. Now the mathematicians are able to calculate, with great accuracy, the exact second that any star crosses the meridian, and as the middle wire in the eyepiece of the transit-telescope is really the meridian, it follows that when a certain star, for instance Vega, touches this central wire, then the astronomer knows that it is exactly, say, 8 hours 5 minutes and 2 seconds. Not only are seconds taken into account, but fractions of seconds also, so that it can be stated exactly, to a hundredth part of a second, when Vega or any other star crosses the meridian. The astronomer, by these means, is able to correct the clock to a very small fraction of a second.

FAMOUS OBSERVATORIES

THE largest of the world's observatories are in the United States, where many wealthy persons interested in astronomy have given money to establish such aids to this science. Our observatories have larger and finer instruments than are to be found anywhere else in the world.

By far the most famous of all observatories is the Lick Observatory. A very wealthy man, James Lick, wanted to build a monument, so that after he died people would have something to remember him by. Certain American astronomers suggested to him that if he wanted to leave

behind him a worthy and lasting monument, it would be a fine thing for him to build a big observatory, which would not be destroyed if America happened to have a war with any other nation. James Lick thought this a capital idea, and gave instructions for an observatory to be built. After a good deal of prospecting to find a suitable place, the astronomers came to the conclusion that the best site for the observatory was on the top of Mount Hamilton, near San José, in California. So it came about that the great observatory was built on the top of this beautiful mountain, and for many years it has given to the scientific world a great amount of knowledge, and discoveries have been plentiful.

One of the conditions that the generous donor made, when giving the money for the building and equipping of the observatory, was that the building should be thrown open to the public every Saturday, and that visitors should be able to come and look through the great telescope at the wonders of the heavens. When we remember that the observatory is situated on the top of a mountain over 4000 feet high, and that the nearest railway is thirty miles away, we should hardly suppose that many people would take advantage of these conditions. The contrary is the case, however; for every Saturday a long string of stages and wagons of all descriptions may be seen far down the valley, slowly making their way up the winding road to the great observatory on the top of the mountain. Sometimes on Saturday night there are as many as 300 visitors who come to view the beautiful objects to be seen in the sky through the great Lick telescope.

Another famous observatory is that near Chicago, called the Yerkes, after its founder, Charles Tyson Yerkes, an American capitalist. Here is a telescope a little larger than that at the Lick Observatory; but the astronomers at the Yerkes are handicapped in a measure, for they have not clear mountain air like that of the Lick astronomers.

The observatory in which English people take special pride is the National Observatory at Greenwich, near London. Here the Astronomer Royal, appointed by the King, is in charge. The work of this observatory includes looking after the time, and matters pertaining to navigation, as well as other departments of astronomy. At ten o'clock and at one o'clock each day, Greenwich Observatory sends what is called a "Time Signal" all over England. To every post-office there is an electrical connection, and at the hours mentioned an instrument in the post-offices gives a big "Click!" and the postmasters of England each know that it is then ten o'clock or one

o'clock, as the case may be. If you happen to be buying a stamp at either of these hours at a post-office, listen for the time-signal. In the window of many an English watchmaker there is a sort of needle that wags furiously at these hours, and each of these time-signals is sent from Greenwich Observatory, the Greenwich astronomers taking their time from the stars in the way that has already been explained.

Greenwich Observatory, too, is situated on the meridian, which means that it is from this point that sailors take their measurements each day, whether far out at sea or close to land. If a sailor wishes to learn his whereabouts on the wide ocean, he must, of course, have some place from which to begin his measurings, and for this point Greenwich meridian, or "longitude o," as it is called, has been in use ever since the observatory was established, some hundreds of years ago. The meridian of Greenwich is called a first or prime meridian, and is most widely used in reckoning longitude. But some countries call the meridians of their own capitals first or prime meridians. In our country we sometimes so call the meridian of Washington.

THE TELESCOPE

Now just a word about the telescope, the instrument by means of which astronomers have obtained most of their knowledge. Some three hundred years ago, in the town of Middelburg, in Holland, lived a spectacle-maker called Lippershay. One day his apprentice was playing with some spectacle-glasses, and suddenly he so arranged the glasses that, as he looked through them, the clock of a neighboring church became large, and seemed quite near. The apprentice was delighted with this, and told his master, who then made the first telescope. But people did not think of looking at the stars with the new instrument, which was not at all powerful as telescopes go. All they thought about was that it would be very useful, in time of war, for their generals to be able to see from a distance what the soldiers of the other side were doing.

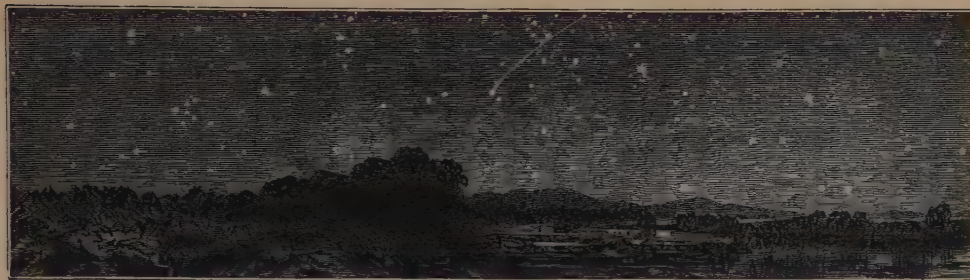
The discovery, however, soon became known all over Europe, and the principle of the invention soon came to the knowledge of Galileo, who set to work to make himself one of these new instruments. He soon had completed one that magnified about three times, being less powerful than opera-glasses of the present time. Galileo did not care about wars or soldiers, and he applied his instrument to the heavens; the wonderful sights he saw, even with such slight optical aid,

soon determined him to make a larger and more powerful instrument. This he did, constructing a telescope that magnified thirty times, and with this instrument he discovered the mountains on the moon, four satellites of Jupiter, saw more stars in the Pleiades, watched the changes of Venus, and discovered spots on the sun. He also saw Saturn, "like an olive," though he never solved the mystery of its rings.

After Galileo's time the telescope became quite a recognized instrument, and great improvements were made as time went on. It was left to Sir Isaac Newton, however, to invent a new form of telescope, which has been most serviceable, and with this new type of instrument most beautiful photographs of the celestial bodies have been obtained in recent years. There are two kinds of telescopes at the present day; these are Galileo's type, called the refractor, and Sir Isaac Newton's type, called the reflector. The first kind is the ordinary "spy-glass" sort of instrument which we look through; but the reflecting telescopes are made on a different principle. They have a large mirror mounted at the bottom of the telescope tube, and this mirror is carefully ground down to a certain curvature, so that when the rays of light from a star, or any other heavenly body, fall upon this mirror, they are reflected back to the top of the tube. Just at the correct point, near the top of the tube, a little prism is inserted, which catches the rays from the mirror and diverts them to the side of the tube where the eyepiece is placed; so that, instead of looking through a reflecting telescope, we look into the side of the tube, and there see the object to which the telescope is directed.

There is a great advantage in reflecting telescopes, because they can be made larger than refractors, and also because they are somewhat cheaper. The largest reflecting telescope in the world is that of Lord Rosse, in Parsonstown, Ireland. The mirror of this great instrument is six feet in diameter, and weighs three tons! The largest refracting telescope is that of the Yerkes Observatory; and the object-glass, upon which the power of this class of telescope depends, is forty inches in diameter.

With the aid of a telescope, bright stars and planets can be seen during the daytime, in full sunlight, provided, of course, that clouds are not in the way. This is a fact of which many people are ignorant, for they think that the stars only "come out" at night-time; but we know that there are always stars in the sky, both day and night, and it is only the glaring light of the sun that prevents us from seeing them with the naked eye during the daytime.



SHOOTING STARS THAT REACH THE EARTH

BY OLIVER C. FARRINGTON

ALL of you have been out of doors on a cloudless evening, and have seen a star apparently fall from its place in the sky, and glide in a long line of light toward the horizon.

Perhaps you have wondered, as I used to do, how long it would be before the stars would all be gone from the sky, since one fell so often. I did not then know, what I have learned since, that "shooting stars" are not true stars at all, but only bodies which appear for an instant, and then disappear forever. Let us call them meteors, and thus avoid confounding them with real stars; for the real stars are as enduring as anything in the universe.

In common speech, however, the term meteors is largely confined to those shooting stars which are very large and bright, and are seen only now and then. Since they do not, however, differ from the shooting stars in any important respect, so far as we know, most of the learned scholars who make a study of such subjects consider them the same.

Now, if meteors never came any nearer the earth than do those which we so often see, we should know nothing more about them than what we could learn from their light, and that would be very little.

But it sometimes happens that one of them can be seen to come directly down to the earth. It makes a bright light as it falls, sometimes so intense as to outshine the sun when that is in the sky. Sometimes the meteor carries with it a cloud of smoke, and falls with a hissing, spluttering noise, throwing out showers of sparks as it descends. Usually, too, loud reports are heard as it passes through the air, as if aerial armies were cannonading one another; and as the sound

of the conflict dies away, long rolls of echoing thunder shake the earth.

When the astonished people thereabout have recovered from their fright and hasten to the spot where the meteor struck the earth, they sometimes find buried in the soil—if the soil has any depth—a piece of stone or metal, often no larger than a hen's egg, but sometimes big enough to be of several hundred pounds weight.

It is usually still hot if picked up very soon after its fall, and its surface will be found to be covered by a thin crust, or varnish, made by the melting and flowing of its outside. This crust on the stones is usually black, while the interior is light gray in color; on the pieces of metal it is of a rusty brown color, and the interior of the mass nickel-white. It may be seen on the stones shown in Fig. 1, representing some of those that fell about 5 P.M. on May 2, 1890, near Leland, Winnebago County, Iowa; and where the crust has been broken off the light-gray inside is seen. The surface of these bodies can be seen, too, to be indented by little pits or hollows which look for all the world as if the mass had once been soft as a piece of putty, and some one had pressed it with his thumb in many places.

These pits are better illustrated in Fig. 2, which shows how they appear upon a stone which at one time fell from the sky, and afterward was found at Long Island, Phillips County, Kansas. This is the largest stone ever known to fall. It is now in the Field Columbian Museum, Chicago.

Because they come from meteors, bodies that fall in this way are called meteorites; and for very many years past all the meteorites which have been seen to fall, or could be found, have been carefully kept, so that they may be studied.

We know, too, that they have fallen in earlier times as well, because the histories of nearly all ancient peoples contain accounts of such occurrences, and of the homage paid to the "sky

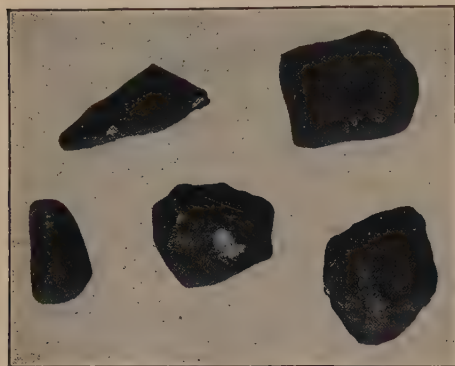


FIG. 1. SOME OF THE STONES WHICH FELL AT LELAND, WINNEBAGO CO., IOWA, ABOUT 5 P.M., MAY 2, 1890.

stones" by those who thought them gifts from the gods, or miraculous objects. It is probable that the so-called goddess Diana who was worshipped by the people of Ephesus was a meteoric stone.

A mass of iron which proved to be a meteorite was found in Texas a few years ago, at the crossing of a number of trails leading in different directions. It was learned that it had been set up by the Indians as a fetish, or object of worship; and whoever passed by was expected to leave upon it beads, arrowheads, tobacco, or other articles as offerings, since it was regarded as having come from the Great Spirit. Another, which fell in India some years ago, was kept decked with flowers, was daily anointed, and frequently worshipped with great ceremony. There is preserved to this day in the parish church of Ensisheim, Alsace, Germany, a stone weighing over two hundred pounds, which fell in the town November 16, 1492. The king, being near at the time, had the stone carried to the castle, and after breaking off two pieces, one for himself and the other for the Duke Sigismund, ordered the remainder to be kept in the church as a miraculous object; and it still hangs there, suspended by a chain from the vault of the choir.

Thus we see that these meteors often reach the earth, and that many have been collected and examined, so that their characters are pretty well known. They all are found to be alike in many respects, and by those who have studied them carefully they can readily be distinguished from anything else found upon the earth.

I have said that they are pieces either of stone

or of metal; and since the characters of these two kinds differ somewhat, I shall describe them a little more in detail.

The metallic meteorites are made up chiefly of iron and nickel. These are alloyed together in the proportion of from 90 to 95 per cent. of iron to from 10 to 5 per cent. of nickel—a ratio very much like that used for making the nickel-steel with which our armored cruisers are plated.

Besides these there are small quantities of the sulphides, phosphides, and carbides of iron, a little cobalt and manganese, and often minute quantities of copper and tin. One or two meteorites have been found which contain also quantities of minute diamonds, too small to be seen plainly, but known by their great hardness.

The most curious feature of these meteorites, however, is seen when a flat, polished surface is exposed for a time to the action of a strong acid. As the polish disappears under the eating power of the acid, there come out upon the surface well-defined bands, or lines, sometimes as much as an eighth of an inch in breadth, and again so narrow as to be seen only with a lens. These cross one another at a great variety of angles and distances, and produce strikingly intricate and beautiful figures. Moreover, these differ in meteorites which fall at different times, and so afford a means of distinguishing between them. Fig. 3 shows the figures which distinguish the meteorites of Laurens County, South Carolina, and Lion River, South Africa. The figures



FIG. 2. THE STONE FOUND AT LONG ISLAND, PHILLIPS COUNTY, KANSAS.

brought out by this etching process are believed to be produced by separation and crystallization of the different substances of the meteorite while they are in a more or less liquid state, the purer

iron separating itself from that which contains more nickel, and these in turn from sulphides and other compounds of the mass.

These, each being variously acted upon by the acid, appear in relief, or depressed below the surface, according as they resist the action or



FIG. 3. WIDMANNSTÄTTIAN FIGURES ON THE LAURENS CO., SOUTH CAROLINA, AND LION RIVER, SOUTH AFRICA, METEORITES.

are readily dissolved. Since the markings were first described by Widmannstätt in 1808, they are called Widmannstättian figures. They were for a long time thought to be peculiar to meteorites, and were supposed to prove that any lump of metal on which they could be brought out had fallen from the sky; but we now know that they appear on some masses of iron which have always been upon the earth, and therefore indicate only a peculiar condition under which the iron showing them was formed.

If the mass on which the figures are obtained has also the crust, pitted surface, and chemical composition such as I have described, there can be little doubt that it fell from the sky, even if no one saw it fall, because all these characters together are not possessed by any earthly bodies so far as we know. A great many of the metallic meteorites now in collections have been obtained in this way, and are known as meteoric "finds," in distinction from meteoric "falls."

The largest iron meteorite known is one that was found in 1581 in the district of Chupaderos, in the state of Chihuahua, Mexico. It is a solid mass having a weight of fifteen tons. Its form is illustrated by Fig. 4 and its size is indicated by its proportion to the man standing near. Not far away was found another nearly as large. Both remained for a long time in the place where they fell, but have recently been moved by the Mexican government to the School of Mines of Mexico, and may now be seen there.

Another large iron meteorite is that which was found at Cross Timbers, near the Red River, Texas, and is now in the Peabody Museum, Yale University. It has an oblong form, and weighs 1635 pounds. It was for a long time in the cabinet of Colonel Gibbs of New York city, and after his death narrowly escaped being lost, because

the workmen who were removing his belongings concluded that such a lump of iron was quite too worthless to be saved. Digging a hole in the earth, they had almost buried it from sight when a member of the family very fortunately appeared and rescued it from its untimely grave.

Another iron meteorite, famous on account of its remarkable form, is that known as the Signet Iron, found near Tucson, Arizona, and now in the National Museum at Washington. It has the shape of a huge seal ring, its weight being about 1400 pounds, and greatest exterior diameter four feet one inch. Other perforated masses are known, but none having so large an opening as this. When first discovered, by Professor Le Conte, in 1851, it was imbedded in an upright position in the soil, and was used by the inhabitants of the village as a public anvil. They seemed to think it placed very strangely but conveniently for their use, and possibly would have hammered upon it for centuries without ever trying to learn its real nature.

Another illustration of uses to which meteorites may be put before their real character is known, is afforded by those of Kiowa County,

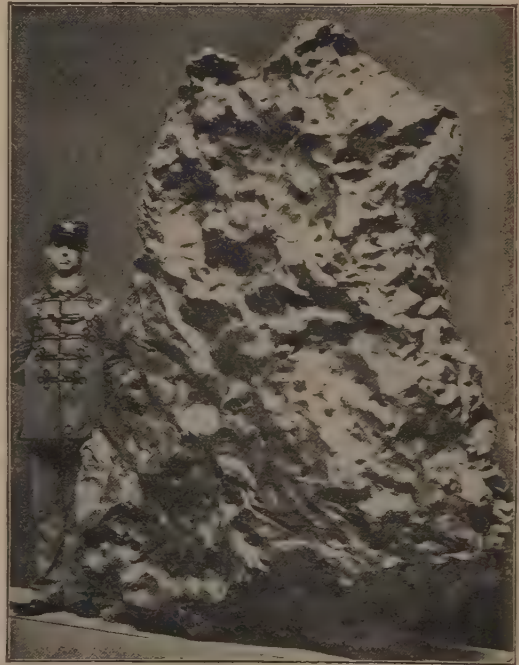


FIG. 4. THE CHUPADEROS, CHIHUAHUA, MEXICO, METEORITE.

Kansas. They fell on a prairie where rocks were scarce and valuable, and the farmers of the vicinity found meteorites convenient for holding down

haystacks, stable roofs, or covers to rain-barrels. For such purposes they might have been used for a long time, had not the wife of one of the farmers become convinced that there was something unusual about them, and called in an expert to examine them. He at once recognized their nature, and the enterprising woman finally sold hers for enough to pay off a heavy mortgage upon the farm.

From meteorites made up wholly of metal there is every gradation through those made up partly

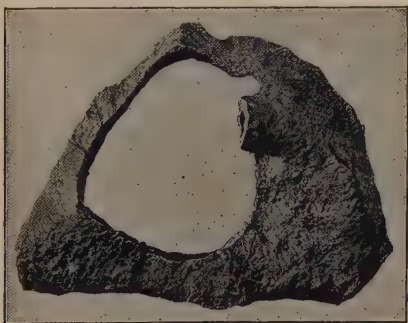


FIG. 5. THE "SIGNET IRON," OF TUCSON, ARIZONA.

of metal and partly of stone to those composed wholly of stone. The latter resemble the rocks found about volcanoes or in the trap outcrops of the earth. They are made up chiefly of the minerals feldspar and augite, or chrysolite and augite. There are, however, very few of them which do not contain some metallic grains, of iron or nickel, which would distinguish them from any rocks of the earth.

Another peculiar feature of most of the stony meteorites is that they contain little balls of mineral fragments scattered through the mass of the stone, like plums in a pudding. These balls, or *chondri*, as they are termed from the Greek word meaning a ball, can be seen, in a section of the stone ground sufficiently thin to be studied with the microscope, to be made up of minerals like those of the stone itself, but arranged in peculiar forms. They may be fan-shaped, radiated, or concentric, and may contain minerals in a fibrous or thread-like condition, or as coarse, angular grains.

The section of the stone shown in Fig. 6 illustrates the appearance of these little balls, and the different minerals of which they may be made up.

Some observers have thought these balls were formed by fragments of rock rubbing against one another till they were rounded. Others have considered them produced by rapid or suddenly arrested crystallization which prevented the minerals from assuming their natural shapes. In what-

ever way they were formed, it is certain that they were made under conditions somewhat different from any which prevailed in producing the rocks of the earth, and thus they aid us in distinguishing meteoric stones from terrestrial rocks.

It is therefore not likely that the stones which fall from the sky ever formed a part of the earth; and, if they did not come from the earth, they must have had their origin somewhere in those vast regions of space where are the moon and planets and all the other heavenly bodies which we can see but can never hope to reach. Because they resemble so closely volcanic rocks, some scholars have thought they were at some time thrown out by the volcanoes of the moon, and so have reached us; but there are many reasons why this cannot have been their origin. Farther away than that they must have been formed, somewhere out in the cold of space, under conditions which we can only conjecture. But because they are the only bodies that ever reach the earth from out of the universe beyond it, and are therefore the only means by which we can judge directly of how the starry worlds are made up and what their history has been, their study possesses very great interest, and some scientific men devote much time to collecting and examining them.

So far no elements have been found in meteorites differing from those of the earth. Those which do occur are just such ones as are most common here, being principally iron, nickel, phosphorus, sulphur, carbon, oxygen, silicon, magnesium, calcium, and aluminium.

Some of the minerals found in meteorites are, however, not known to occur upon the earth, and

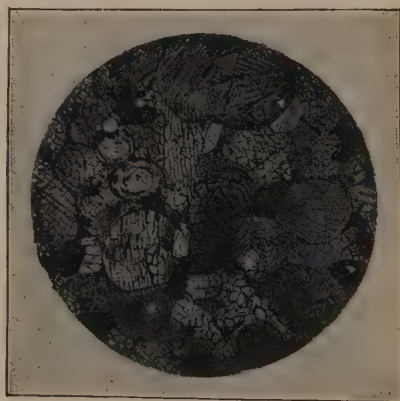


FIG. 6. A SECTION OF THE STONE WHICH FELL AT HOME-STEAD, IOWA, AS SEEN UNDER THE MICROSCOPE.

show that the conditions under which they were produced were different from any that exist here. Thus the iron in them, instead of being rusty or

oxidized, as it would be if exposed to the action of water or air, is in pure, metallic form. They contain also a mineral formed by the union of phosphorus and iron, which could not have been made in the presence of oxygen. We know, therefore, that neither water, air, nor free oxygen existed in the worlds from which these bodies came.

A great deal of pains has also been taken in studying these meteorites, in order to learn whether they give any evidence that living beings existed in the regions from which they came. So far, however, no such evidence has been found. Some of them contain pitchy substances such as are on the earth probably formed by plants; but it is not at all certain that they could not have been of mineral origin.

So far, then, as we can learn from meteorites, we find the heavenly bodies to be made up of elements and minerals like those which compose our earth, and to be uninhabited by any living things.

Let us now go back for a moment to the shooting stars, and see why they do not all reach the earth. We know that we live at the bottom of an ocean of air, which we do not ordinarily see or feel, but which is made up of molecules no less real than those of water or of iron. We become conscious of this when the wind blows hard, because we can then see the effects of the striking of

these molecules against any solid body, or we may even feel them cutting against our faces. Any solid body passing through the air encounters these molecules, and by friction against them is heated just as a car-wheel gets heated from friction produced by the application of the brake. The greater the velocity of the solid body, the more highly it will be heated, as can be proved by the temperature produced in a wire passed through the air at different velocities. So one of these pieces of stone or metal which is moving in space, and traveling at a very high rate of speed (usually not less than twenty miles a second), upon its entrance into the earth's atmosphere immediately encounters a great resistance from the air, and is very soon intensely heated. In this intense heat it glows so that we see its light, and unless it is of large size it will soon be burned up.

We then have seen a shooting star, and we never shall see it again. If, however, the mass is so large that it gets to the earth before it is burned up, a piece of stone or metal such as I have described will be found where it has fallen; and one more meteorite will be added to the collections which already form a prominent feature of the different museums of the world. And by the study of these meteorites we hope to learn something about the worlds beyond ours.



A SHOOTING STAR.

NATURE'S CURIOSITY SHOP

PART I

WHAT MAKES A BALL BOUNCE?

THERE are two kinds of balls that bounce—those which are solid, like a hard india-rubber ball or a golf-ball, and those which are hollow, like a tennis-ball, covered or uncovered. No matter whether a ball is solid or hollow, its bounce is due to the fact that it is what we call elastic. This simply means that when the ball is pressed out of its shape it tends to return to the shape it had at first. It is this return to its original shape, or rebound, that makes the ball bounce.

We must not, however, think that only india-rubber is elastic. On the contrary, steel is much more elastic than india-rubber, and, as can easily be proved, steel balls bounce splendidly.

WHAT MAKES A BALL STOP BOUNCING?

INTO almost every question we can ask, there comes, sooner or later, the greatest and deepest law of all science, which is that nothing is lost or created, and that everything has to be paid for. This law of the persistence of power applies to the movement of an atom or a star, a butterfly or a ball.

When the ball starts bouncing, it has a certain amount of motion in it, which is force, or power, or energy. When it stops, that has gone. Either we must show that the energy has gone somewhere and has not been destroyed, or, according to the great law of the persistence of power, the ball should bounce forever. If it did not bounce forever the law would be false. It is, however, quite easy to show that the ball does lose the power with which it started. To begin with, it is moving, both up and down, through the air, and forcing millions of particles of air aside every moment. All the motion it gives to them it loses.

If a ball were bounced in a space as far as possible emptied of air, it would bounce far longer than it does in the atmosphere, just as a top will spin longer in the same circumstances.

Suppose that, instead of bouncing the ball on something hard, we bounce it on a pillow or on loose sand. It will not bounce long in such a case. Its power has gone in moving the pillow or the sand as well as the air. The ball itself, too, is not quite elastic, nor is the ground. If the ball and the ground were quite elastic, and there were no air to move, and the ball never turned and rubbed the ground in falling, it would go on bouncing forever.

WHY WILL NOT A BALL BOUNCE WHEN IT IS BURST?

IN the case of a hollow ball, such as a tennis-ball, which has a splendid bounce, it is not by any means the india-rubber only that explains why the ball is so elastic. The ball is filled with gas, or, rather, a mixture of several gases, which we call air. We can soon notice how much this ball bounces if we compare an ordinary soft india-rubber ball, perfectly tight, with one which has a small hole punched in it.

So far as the india-rubber is concerned, the two balls are practically the same, but their bounce is very different—unless we happen to bounce the second ball just on the place where the hole is. If we do not do this, the air is expelled from the hole when the ball is bounced, and we find that it bounces very little, because the elasticity of the ball is so poor. But the other ball bounces exceedingly well, because, when it is bounced, the air in it is not squeezed through any hole, and thus gives the ball its elastic rebound.

WHY DOES EVERYTHING SPIN ROUND WHEN WE ARE DIZZY?

WHEN any one feels dizzy, and perhaps almost about to faint, his brain cannot properly control the working of his eyes. They may move round from side to side, perhaps independently instead of together, and so it may look as if things were spinning round. Another reason for dizziness

has to do with a wonderful part of the body, a canal system in the middle ear, without which none of us could sit upright, much less stand, though few people have ever heard of it. This organ, which used to be thought to have something to do with hearing, really controls our balance. In some people it is injured by disease, and its subjects often suffer from dizziness and a feeling that everything is spinning round and round.

As every child knows, we can make ourselves dizzy, and can think that everything is spinning round, by turning round ourselves several times in one direction. This disturbs the organ of balancing, about which we have been speaking, and this disturbance it is that gives us the feeling. If you turn round the other way you put things right, by restoring the original state of affairs within the balancing organ. The name for the feeling that things are spinning round is *vertigo*; and *vert* simply means *turn*, as in such words as convert, invert, and others.

DOES A TADPOLE KNOW IT WILL LOSE ITS TAIL?

OF course, we cannot speak of a tadpole, or any such creature, knowing anything in any such way as this question suggests. A tadpole, a fish, an insect, may know, in the sense of recognizing, a thing that it has seen before, and remember whether it is nice or not. A dog, an animal of very high intelligence compared with a tadpole, may know when its master is angry; may know when it is doing a thing which is disapproved of. But not even a dog can ever *know* in the sense suggested by this question.

Let us consider what the point is. If a tadpole is to know that it will lose its tail, this means that it has arrived at the idea of itself as I, and that it is able to think of itself in the future and what will happen to it. In other words, the tadpole must be conscious of itself. But this consciousness of ourselves, or self-consciousness, is found in no living creature but man, and is, beyond all other things put together, the fact which distinguishes man from every other form of life on the earth.

Even a human baby does not have self-consciousness. Tennyson has said:

The baby new to earth and sky

Hath never thought that this is I.

When a baby learns to talk, it first speaks of itself as baby, and only gradually discovers itself,

and speaks of I. Then it has become really human. If a tadpole knew that it would lose its tail, the power to do that would at once place it on a level with ourselves: it would be no tadpole.

At a certain stage in the life-history of a tadpole some of the cells within the tadpole's body begin to attack and devour the cells that make up the tail. The tail is gradually eaten away and absorbed until finally, by the action of these cells, there is nothing of it left. The material thus disappears, by the process which is known as absorption; it is "used up" by something else.

WHY DO WE GET TIRED?

THE answer is that tiredness or fatigue is due wholly to the poisoning of the brain and the nerves by all sorts of things which are produced in our bodies as the result of work; or perhaps sometimes, as most children know, as the result of too much exposure to sun and heat.

Every day's work, if it is at all hard, produces rather more of these poisonous things than we can quite get rid of as we go on working; and these things really help us, at night, to go to sleep. During good sleep they are all got rid of, and we wake refreshed.

It is easy to show that this new discovery about tiredness is true. We can take a small quantity of blood from a tired animal, such as a dog, without hurting it, and can give this to another dog that is not tired. The second dog at once shows all the signs of a dog that has run a long way and is quite tired out. The poisons produced in the body of the first dog and carried in its blood have got into the blood of the second dog, and it too feels tired.

WHY IS ICE SLIPPERY?

WE say that a thing is slippery when its resistance to motion along its surface is very slight. This resistance, or friction, is a thing we rather dislike—especially in machinery; but we should find things very inconvenient without it. Walking and running would be utterly impossible without friction, and even standing still would require the most perfect balancing. When we walk on ice, we get as much friction as possible from our boots. If we tried to walk on boots soled with ice, or covered with an even layer of oil, we could not walk at all, for there would be practically no friction to keep our feet where we planted them. The absence of friction in the case of ice depends upon its beautifully even, crystalline structure.

The molecules of water are held together very

smoothly and evenly, and this is especially so if the ice formed when there were no currents in the water and no wind, so that its surface was very smooth when it became frozen. Various substances, like oil and wax and varnish, will give an extremely smooth surface even to things like wood, and so render them almost free from friction. When we skate, we use a metal surface as smooth as possible, both on the flat and on its two edges, and though there is no small amount of friction when the blade cuts a line in the ice, yet it is not enough to prevent us from sliding on the skate-edge for many yards at a time.

WHY DO ANIMALS IN SNOWY COUNTRIES WEAR WHITE COATS?

THE use of the white coat is to protect the animal from its enemies by making it difficult to see. If the animal keeps still it can scarcely be seen at all when its coat is the same color as the snow. But if it had a white coat in summer, when the snow goes, it would be easily seen, and so its coat often changes in summer, and the fur takes other tints, more like the color of the ground and the plants among which it lives. This is called *protective coloring*, and is very useful to many animals. But sometimes it happens that an animal which lives by catching others is also white in winter snow, so that it can get near its prey without being seen. Some insects do the same thing, and when they sit quietly among the leaves of certain plants no one can tell which is insect and which is leaf; so the birds that would eat them up cannot find them.

IS IT GOOD FOR US TO LAUGH?

THE old saying, "Laugh and grow fat," suggests that it is good for us to laugh, though perhaps growing fat is not the best proof of that. At any rate, it is perfectly true that we do derive some benefit from laughing. To put it more generally, it does our health and lives good to be happy, whether we actually laugh or not. As Herbert Spencer put it long ago, "Every pleasure tends to raise the tide of life, and every pain tends to lower it."

This can be proved in detail by careful study of the different things that the body does. For instance, happiness strengthens the beat of the heart and deepens the breathing. If food is eaten with pleasure, in good company, and with an easy mind, plenty of the digestive juices pours into the stomach, and the fluid, when examined chemically, is found to contain a high proportion of ferments by which digestion is done.

On the other hand, digestion does not go on nearly so well if we are not happy; and it is known that often, when people are really worried or unhappy, either the stomach will not keep the food at all, or, if it does, no digestion occurs. In great sorrow it may actually be impossible to swallow even liquid foods.

Laughter has a special value of its own, for it is a kind of exercise of the most important and valuable muscles in the body—the muscles by which we breathe. And this extra-deep breathing not only exercises the muscles of the chest, but also indirectly exercises the heart. It also means that more oxygen passes into the blood, and that the blood, richer than usual in oxygen, is carried more quickly than at ordinary times to the various parts of the body.

WHY CANNOT WE JUMP OFF OUR SHADOWS?

WHEREVER we go, our shadows will follow, of course. We all know what makes shadows, but we do not all know what wonderful things shadows make. For instance, the moon is lit by the sun's light; and sometimes the earth "gets in the light," as you do when you stand in front of the lamp some one is reading by. So the earth prevents the sunlight from reaching the moon, and throws a round shadow, which we can see across the moon as the earth gets in the way. This is an "eclipse of the moon."

Then shadows make strange things when they are thrown far away. The shadow of your hand becomes very big if it is thrown on a wall far off. And sometimes the shadow of a man's body may look like a strange giant and frighten the man who is making it! There is a mountain in Germany, called the Brocken, nearly a mile high, where a man's shadow is sometimes thrown on the clouds.

WHAT IS THE GOOD OF HAVING TWO EYES?

WE may say that perhaps it is not worth while having two eyes, since we seem to see just as well with one as with two. But sometimes we may have noticed that we or other people, in pouring milk or putting a lump of sugar into a teacup, have made a mistake, and have put the milk and sugar in the saucer. That is what is very likely to happen to any one who uses only one eye. The two eyes do not look at anything from exactly the same place, but from rather different "points of view," as we say. The brain takes these two "points of view" and sees from both of them together; so

that it is very much helped in judging of the distance of things by the difference between the two images of it seen by the two eyes. It is because we have two eyes that we see things in their relation in front of or behind each other. An ordinary photograph looks flat, because, so to say, the camera only saw it with one eye. But if we take two photographs of a thing, from two points of view corresponding to the distance between the two eyes, and then put the two photographs side by side at the right distance, and look at them with both eyes, through the simple little instrument called a stereoscope, or "solid see-er," then we see the view as if it were solid, or see it "in relief," as people say. We see it as we should have seen the thing itself if we had looked at it with our own two eyes.

HOW FAR CAN WE SEE?

WHEN we say that our eyes see, all we really mean is, that light has entered them and has affected them. If that happens, we see. It does not matter whether the light has been produced by a match that some one has held just in front of our eye, or whether the light has come from a star so distant that its light took ten thousand years to reach us. In either case, if light enters our eye in sufficient quantity to affect it, we see. This is quite simple when we come to think of it, but most people are confused about this question because they do not ask it quite rightly, another proof of that saying that everything depends on putting the question rightly to Nature. We understand now that our eyes can see to any distance from which light can reach them. Of course, the question whether the light has traveled billions and billions of miles, or only half an inch, makes not the slightest difference to our eyes.

It is quite a distinct question at what distance our eyes can distinguish the details of a particular thing. This depends on a great many things, but it can be reckoned to some extent, and it is very important to do this for the case of different telescopes. We know that, if there were any building on the side of the moon next to us as large as the Capitol at Washington, it could be made out in our best telescopes.

WHY ARE BLIND PERSONS SO QUICK AT HEARING?

THE simplest answer to this question would be to say that blind persons listen more attentively to the sounds around them; but it will be well to explain a little more than that. An ordinary per-

son who has all the senses of sight, smell, touch, hearing, and taste receives a tremendous number of impressions from all sorts of sources, which are conveyed to his brain by special nerves and give him the ideas which he identifies with all those sensations. Now, if one of these nerves, or brain-centers, should be destroyed or absent, the brain has fewer messages to attend to, and so has more time for the rest.

Thus in a blind person there are no means of his getting all the information which comes to an ordinary person through sight; so that if he wants to know how near he is approaching to somebody walking toward him, the only means he has of judging that is by listening to the sound of the footstep. He cannot see the distance which separates the two. Therefore he becomes accustomed to listening deeply for all the sounds around him, many of which he would otherwise not hear at all. In this way the blind become extremely quick at hearing.

WHY DO TWO SIDES OF A ROAD MEET IN THE DISTANCE?

OF course, we know that the sides of the road do not really meet, but they seem to meet. If an artist is showing us a road going away from us in a picture, he must really draw the two sides of the road toward each other, so as to give the eye the same impression that a real road does. This is a part of the study which artists call perspective—how things look when they are *seen along*, which is what the word means. Our eyes judge by the angle between things. Let us suppose that we use only one eye, to make it simpler; then, if you look at two dots, you judge of the distance between them by the width of the angle between the two lines from them to your eye. Now suppose the same two dots, the same distance apart, were much farther away from the eye, then the angle between the lines is much narrower, and, in consequence, they seem much nearer together. If we imagine that the dots are taken on the sides of the road, at different distances along, then we shall see why the sides seem to meet in the distance. They do not really get nearer, but the "angular distance" between them gets smaller.

HOW CAN A SOUND COME INTO A ROOM THROUGH A WALL?

WHEN a sound-wave, traveling in the air, reaches a wall, it communicates itself to the wall, which is thrown into waves of exactly the same shape and number in each second, but of rather smaller size,

for a little power is lost in transferring the waves from one thing to another.

The waves travel on through the new medium, as it is called, and then are conveyed by it to the air on the other side of it, just as the head of a drum, when beaten, shakes the air next to it into waves. In this second transference back to air again a certain amount of power is lost, and so the sound is a good deal weakened by having to pass through the wall.

Of course, the extent of this weakening will depend on the thickness and on the material and structure of the wall. If we have materials like wool or sawdust or heavy curtain-hangings, which vibrate very badly and with much difficulty, they will absorb most of the sound-wave and it will become faint.

WHY DOES A BOY'S VOICE BREAK AND NOT A GIRL'S?

WHEN a boy's voice breaks, it is because his voice-box is suddenly becoming rather larger. As a girl grows up to be a woman, her voice-box grows steadily in proportion to the rest of her body. But, for some reason, Nature prefers that men shall have much deeper and louder voices than women. In order that this shall be so, the larynx, or voice-box, must be much larger in proportion, and the vocal cords longer in men than in women.

This special change usually begins to happen when a boy is about fourteen or fifteen years of age. It is not really necessary for a boy's voice to break—that is to say, it is possible for his voice to get steadily and evenly lower. But, as a rule, this does not happen, and the reason is, not that there is anything the matter with the boy's voice-box, but simply that he has not learned how to work it.

The muscles are getting bigger and heavier, the cords are getting longer, and this is happening very quickly, and, of course, it must mean that a new skill has to be acquired, just as if one had learned to play perfectly on a very small violin, and then had to play on a full-sized one. That is why the boy has not the proper control over his voice, and sometimes speaks in a low pitch and then suddenly in a high one.

WHY DOES NOT A NEEDLE GAIN WEIGHT WHEN MAGNETIZED?

THIS question puzzles us because we have not clearly distinguished in our minds what weight really is and what it is not. All weight is a direct

consequence of gravitation, and of nothing else. Were there no gravitation, there would be no such thing as weight. The power of gravitation entirely depends upon the amount of stuff that is concerned, or the mass of matter that is acted upon. In other words, the weight of a thing depends entirely upon its mass—the amount of matter in it. Everything goes to prove that nothing affects gravitation except this question of the amount of matter present.

If we take a needle and heat it or cool it, magnetize it or unmagnetize it, or do anything else to it, so long as we do not take away any of the matter from it or add any new matter to it, its weight remains the same. When we magnetize it, we endow it with a new power that is very strong and wonderful, and can be brought to bear in such a way that, for instance, it will overpower the force of gravitation, and will thus enable the needle to lift ten times its own weight. But the weight of the needle itself absolutely depends upon its mass, and upon nothing else. Our bodies weigh just the same whether we hold a weight in our hands or not; the amount of stuff in our bodies is the same in either case. Of course, our bodies and the weight together weigh more than our bodies would alone, but that is a different thing.

WHAT MAKES AN ARROW FLY?

THE motion of the arrow through the air is a kind of power, and that, like all other power, has to come from somewhere. It was not in the arrow when it lay in the quiver, nor even when it was put in the bow; but when the cord was released and pushed the arrow, the arrow got its power of motion.

The power, then, came from the stretching of the bow; for if the bow were not stretched it would not drive the arrow; and so, if we trace the power backward, we find it came from the strong muscles of the archer who bent the bow. But the question for us is: What happens in the bow when it is stretched? All we can say is that when the cord and the bow are bent out of their natural shape by being stretched, they somehow carry in themselves, ready to act, the power they have got from the muscles which stretched them.

The same applies to many other cases where there is hidden power. If we carry a stone from the bottom of a cliff to the top, there is even less difference in its appearance than there is when a bow is stretched; yet it is different, for it has the power we put into it when we carried it, and if it drops from the cliff on our head, as we walk

below, we shall be sure that that power is something real.

WHY DO NOT SPIDERS GET CAUGHT IN THEIR OWN WEBS?

It is the strength of the spider that prevents him from getting caught in his web, which is only made for catching creatures much weaker than himself. We know for certain that the spider can cut his web when he pleases, so that there is no fear of his getting caught in it. The spider is a wonderfully clever animal, but he is not brave. If an insect that is too big for his taste comes against his web, he will sit quite still in one corner and never move until it goes away, and sometimes he is so frightened that he simply cuts his web rather than get into difficulties with something that is more likely to eat him than the other way about. In this he is cleverer than some men, who make nets to catch other people and get caught in them themselves. In proportion to his size, the spider is a very strong animal, and it is really wonderful that he can cut his own web, for they say that in proportion to its weight it is the strongest thing known—stronger than steel.

DOES A WORM BREATHE UNDERGROUND?

EVERY living thing breathes, whether in earth, or on the earth, or in the sky, or in water. If it cannot get air it dies. The worm really has no trouble at all, for there is plenty of air and to spare in the earth anywhere near the surface, and it just helps itself. Of course, if you dig deeply into the earth, there will not be enough air for a thing like a worm, which needs a good deal; and the only living things you will find are certain microbes, or tiny plants, which need very little air. Still farther down you will find no living things at all. There is no life in the inside of the earth.

HOW IS IT THAT WHEN A WORM IS CUT IN TWO IT STILL LIVES?

ALL animals except the very lowest depend upon what we call a nervous system, which controls the power of movement, and so forth. Now, when this nervous system is all heaped together in the form of the brain, as it is in man and the higher animals, the life of a creature depends upon that brain being uninjured. But in lower creatures, like the worm, the arrangement of the nervous system is different. It is more scattered

over the body, and so, when a worm is cut in half, there is enough nerve matter in either half of the worm to enable it to keep living.

HOW CAN A DUCKLING SWIM WITHOUT BEING TAUGHT?

HERE, as in many other cases, we must say that the answer is, partly, instinct. It is only fair to remember that in any case it is very much easier for animals to swim than it is for us; and it is also fair to us to remember that some people do swim almost without being taught, and, indeed, that we should probably all be able to swim in a kind of way without being taught, even though our bodies are not at all suited for swimming, if it were not that a man who has not learned to swim is frightened in the water, and throws his arms up, which is just as if he made his body heavy, and so he sinks.

Now, sometimes an insect, which has never seen any one do the thing it has to do, does it perfectly. But in the case of the higher animals, like the cat and the duckling, the question of being taught comes in, if it be no more than merely by imitation. The kitten may partly learn to purr through hearing its mother purr, and the duckling, though perhaps its mother does not actually teach it anything, yet at least gets confidence from its mother. It knows she is there, and it sees that she can swim, and that helps it. We do not say that a duckling could not swim without being taught, because it could; but we think it would learn earlier with its mother's help than without it.

WHY DOES A DUCK NEVER GET WET?

THERE are really several reasons. For one thing, the feathers that cover the body of the duck are very thick and very smooth. They are so thick that the water on which the duck is floating does not come in contact with the air underneath them, and so the skin of the duck is kept quite dry and quite warm.

But this by itself would not be enough. There is a structure called a gland, which has an opening on the back of the duck near the tail. The business of this gland is to make oil, or grease, and quite a lot of oil is produced from it. This oil is used by the duck to smear over its feathers to make them extremely smooth and slippery, just as oil is used to lubricate a bicycle. Now, it is a very curious thing that oil and water will not mix, and so the duck—like any other bird that lives in the water—having covered its feathers with a thin layer of this oil, prevents the water from

wetting them. Thus the duck keeps its skin and feathers dry. As a matter of fact, the water does not affect the duck at all, and this gives rise to a common saying: if anything happens to a person, and that person takes no notice of it, it is said that he is like a duck, because he is no more affected than the duck is by the water on its back.

HOW DO SNAKES MOVE ALONG?

To watch a snake or a serpent gliding smoothly and silently along the ground is to see one of the most marvelous things in natural history. Indeed, the wisest man who ever lived confessed that the motion of a snake was one of the things that he could not understand. Three parts of the snake's body take part in its movement—the backbone, the ribs, and the large horny scales underneath. It is by muscles moving these parts in certain ways that the snake glides.

As a matter of fact, a snake walks on the ends of its ribs—a very curious use for ribs to be put to. These ribs are very numerous, there being one for each part of the backbone. Each rib is also fixed to one of the large belly-scales. By the muscles acting on the ribs, these scales are moved forward one after the other, their edges catching the ground, and the result is a rapid gliding motion. We notice that the body always moves from side to side in a wriggling or writhing manner, never up and down, as is sometimes shown in pictures. It is the very flexible backbone that allows of this writhing movement, and the structure of the backbone also allows of its being broken rather easily.

So that the movement of a snake is really very like what happens when a boat is being rowed through the water. The ribs correspond to the oars, the ribs gripping the ground by the scales to which they are attached, just as the oars grip the water—only the snake's back is flexible, while a boat is rigid. Therefore, if we watch the snake in motion, we see the movement pass along its whole length in a wavy manner, as each rib on each side moves after the last in rapid succession.

CAN A POISONOUS SNAKE BITE IF IT LIKES, WITHOUT POISONING?

SOME can and some cannot. The way that poisonous snakes use their fangs to inject poison is one of the most wonderful things in the natural world; and in the case of some snakes—for instance, the European adder or viper—the poison-fang and its venom are only used as a means of self-defense, or for getting food.

But the adder as a rule does not use its poison-fang when it bites the animals on which it feeds, and so it has a very curious arrangement, by means of which its fangs are laid flat back in the roof of the mouth out of the way of the ordinary teeth which are used for feeding. Thus the adder can use one or other sets of teeth just as it likes when it wishes to kill its foe, and it can tuck its fangs securely out of the way and use its ordinary teeth when it wishes to swallow a mouse. In some of the other poisonous snakes the fangs are fixed, and cannot be used in this way.

WHAT DOES THE HEN MAKE HER EGGS OF?

ALL birds lay eggs, but what we commonly call a hen's egg, with its shell, consists of a good deal more than the real egg, which is the growing part of a chicken. In fact, most of the hen's egg is made of substance secreted by a special organ in the body for the purpose of nourishing the growing chicken within. This nourishing material is what we call the yolk. It is made, of course, from the food upon which the hen feeds, which becomes changed by digestion, and is carried through the hen's body by the blood. Then, in a special part of the body, the proper elements are taken from the blood and made into the yolk, upon which the growing chick feeds. The whole thing is then covered with a shell, which is also secreted from the things upon which the hen feeds.

If we look at an egg that has just begun to develop, we can see just at one point on the surface of the yolk the little thing that will be the chicken; and a day or two later we can see tiny little blood-vessels spreading out from this point over the yolk, so as to help themselves to the food in the yolk. Afterward the white of the egg is also eaten up by the chicken. The white of an egg consists of albumen and water. Albumen means the *white* thing.

This egg-albumen is not the same as the albumen which is in our blood and on which our bodies feed, but it is really very similar. When it is eaten up by the developing chicken, or when we eat the egg, young chicken and all, this egg-albumen is changed by digestion into the blood-albumen of the chicken or of ourselves, as the case may be. As nearly all the egg is nourishment for the young creature that is to develop, different kinds of eggs vary very much in size quite apart from the size of the creature that is to develop from them. Some creatures are born from eggs which contain no nourishment, as the nourishment is supplied in other ways.

CURIOSITIES OF ANIMAL LIFE

COONIE

BY ERNEST THOMPSON SETON

"RANGER" was a good hound. I had taught him myself so that he might teach me. At night I used to go out into the black woods and say, "Ranger, go ahead; let 's see what 's in this wood." And away he would go, sniffing about among the leaves for the foot-scent of the various animals, and for each different kind he had a different "tongue," or cry, so that I knew just what he was after.

During these night hunts I often heard the song of the Saw-whet owl, a high-pitched but soft quavering:

"Whil-il-il-il-il-loooo."

And of this Ranger very properly took no notice, his business being wholly with four-foots. But one night after he had loudly announced the treeing of some creature, I heard the peculiar owl-song, once, twice, thrice.

As I drew nearer, the sound came from the top of a low stump at which the hound was baying. I thought that Ranger was saying, "*Coon, coon, coon,*" but the owl cry puzzled me till I came very close and noted, first, that it was too squally for the Saw-whet, and later that it came from a tiny baby Coon all humped up on the top of the stump, glaring green glares at the dog.

"You poor little Coonie," I said. "You strayed away from your mammy, did n't you?" But his only response was to turn his green-lighted eyes defiantly on me.

I took off my coat, gently put it over him, and in spite of some small growls I bundled him up and took him home.

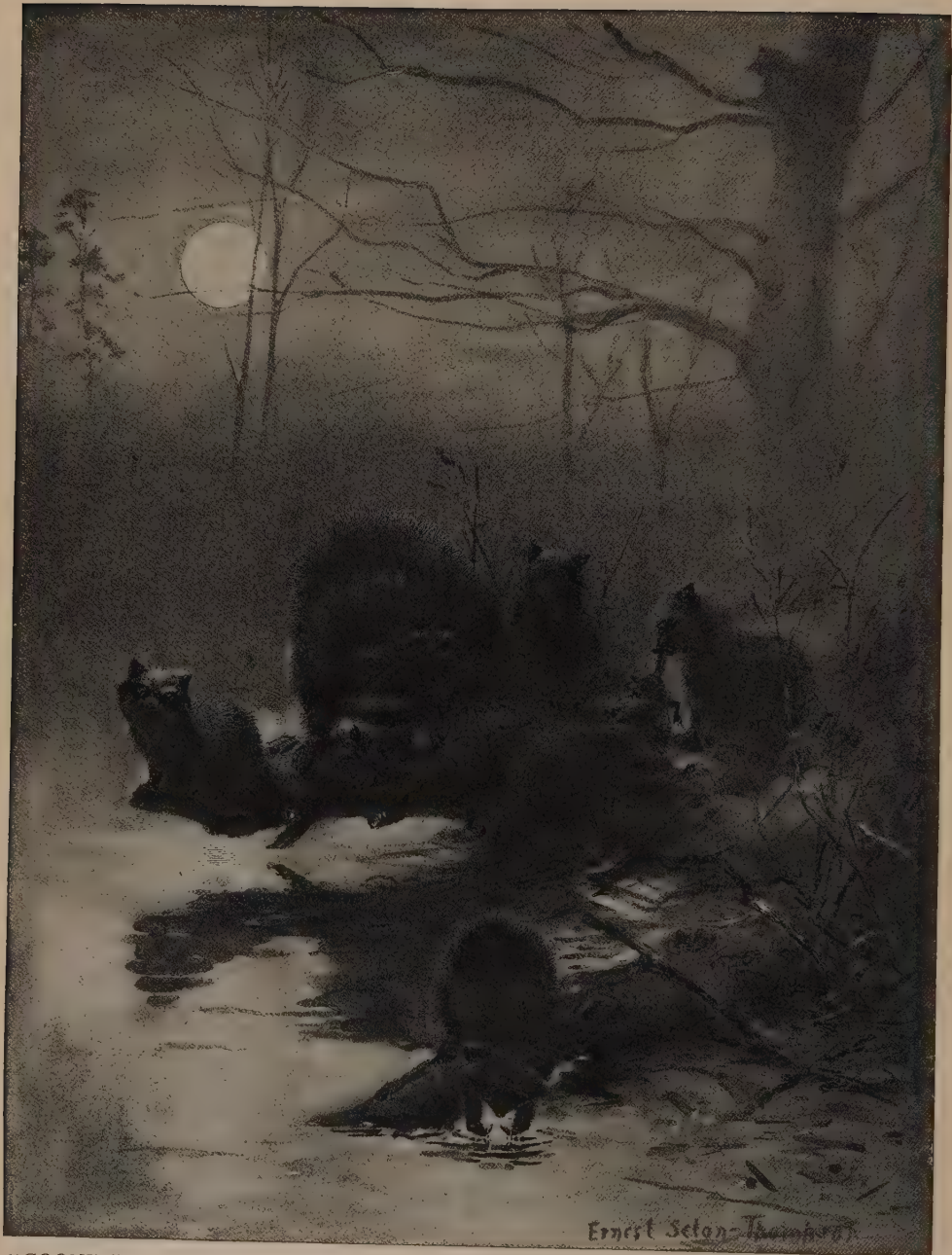
Next morning I went to the place to learn more about my captive's midnight adventure, and as nearly as I could gather from the tell-tale tracks in the mud along the creek, he had been brought by his mother, with his brothers, down

to the shore, so that they could play in the moonlight and learn to hunt. Most of them were careful to keep close by their mother, but one independent or perhaps disobedient cub strayed off by himself, and at the alarm of the hound he did not follow his mother with the rest, but thought he knew enough to select a tree for himself, and of course that tree turned out to be a low stump, the one on which I found him besieged by the dog.

Some Coons have bad dispositions and can never be made really tame, but most young Coons are mild and teachable. This little one was not too old when caught, so he soon became quite tame and gentle.

It is a charming sight to-day to see him curled up asleep with Ranger, his former dreaded enemy, now his staunchest friend. His fear of myself is so entirely gone that at this very moment when I am trying to write about him he is going through all my pockets in the hope of finding, as he certainly deserves to do, some forgotten peanuts or candy.

He rarely utters the owly "*whicker*" now, and I began to think he had forgotten that night when he went with his mother to the margin of the water and dabbled as we see him in the foreground of the picture. But one evening when the coon call was heard outside, he ran to the window, looked quickly and keenly into the darkness, then answered softly, and I could see that though quite used to his new life and at home in the house, he was still, away down in the depths of his little coon heart, just exactly what he was born to be—a fur-clad forest burglar, wearing a black domino, delighting to dabble in the mud, and truly at home nowhere but in the gloom of the midnight woods.



"COONIE" DABBLING IN THE WATER, WITH THE REST OF THE FAMILY NEAR BY.



QUEER STEEDS

BY C. F. HOLDER

"Whoa, chick! Whoa, bird!" somebody was saying.

A stroller along a road in southern California heard the words, and wondered at such unusual terms for horses. The road led out of a little village into the country, and was lined with golden poppies, while here and there brown-backed violets peeped through the green grain that, dropped from some hay-wagon, was now springing up all along the wayside.

The stroller was observing the flowers intently, so did not look around until "Whoa, chick! Gently, bird!" came right over his shoulder, so near that he sprang to one side, turned quickly, and in much astonishment stood facing the queerest team ever seen by anybody anywhere. Standing so close to him that one of the steeds reached over to peck at a flower in his hat, were two fuzzy, grotesque birds of gigantic size, in fact the largest birds in the world—ostriches—harnessed side by side to a curious sulky-like vehicle that had three wheels like a tricycle. On the seat, holding the reins, sat a young man with a pleasant smile on his face, which broadened into a laugh as he saw the evident surprise of the startled observer.

"They're a little kittenish and skittish yet," he said, as one of the birds leaned over and pecked violently at the flower in the stranger's hat. "They can't kick, but they will eat anything in sight. Whoa, chick! Whoa, bird!"—as the birds made a joint effort to reach the bearer of the flowers, who now, laughing, backed out of reach of the strange team.

"Don't be afraid," said the driver, touching the bird-horses with his whip as they made another convulsive effort, lunging heavily toward the poppies. "They can't bite you; see, they're muzz-

led." And then the man with the flowers noticed the clever way in which the birds were harnessed. Around their necks was a strap, while another strap held their beaks together so they could not bite.

"We have to muzzle them," continued the communicative driver. "They'll eat anything—from nails to oranges. Last week one bird swallowed a pipe—and lighted, at that; just snatched it out of a man's hand. But that is n't their steady diet; no. They live on alfalfa-grass and vegetables and ground-shells and pebbles."

The birds were harnessed not unlike horses. Heavy leather collars fitted the lower part of their necks, forming breastplates that were attached to the end of the wagon-shaft and to each other; leading backward were traces that passed beneath the wings. The reins were not attached to their heads, but to their backs.

"They're just broken in," said the driver, "but they travel pretty well"; and he touched the birds with the short whip and spoke to them. They looked around with their great black eyes, and then, as though what he wanted had suddenly occurred to them, started, gradually settling into a very moderate trot, turning easily and coming back up the road again.

"You see they are harnessed in to stay," the ostrich-driver said as he stopped his team. "There are only two things they can do: stand in harness or go ahead. As a rule, they prefer to go. There's only one trouble—I can't get any great speed out of them."

At the South Pasadena ostrich-farm, where one hundred birds of all sizes can be seen, from chicks to full-grown specimens, a boy rides one of the large birds bareback. At first the feathery steed protested, but gradually it became used to it, so

that the young rider goes along with all the ease imaginable, and the picture shows him quite master of his mount.

"Curious thing, that neck," continued the driver, leaving his seat and unmuzzling one of the birds. "Watch it."

Taking from his pocket an orange, he held it out. The bird eagerly seized and swallowed it, and the orange could be seen as a large lump

constant turmoil. Some lazy goldfishes that had always lived a quiet life in that pond were greatly terrified.

The sturgeons coursed about the sides of the lake, and it was several days before they became contented and swam leisurely around. After they had been in confinement for three weeks and were thoroughly at home, the training was begun. A sort of harness was made of canvas to fit over



"TWO FUZZY, GROTESQUE BIRDS HARNESSSED TO A SULKY-LIKE VEHICLE THAT HAD THREE WHEELS LIKE A TRICYCLE."

passing all the way down the long neck—which was an extraordinary spectacle.

A few minutes later the driver touched his strange team, and away they went to the stable, or corral, in the neighboring farm.

Several years ago a gentleman hit upon the notion of taming fishes to draw him about a lake upon his country place. The water was stocked with large German carp that eagerly followed their owner round the edge; but they were rather too delicate to harness, although if enough had been attached they would probably have moved the boat gradually. A number of fishes were thought of, and finally the sturgeon was selected. Soon after two large fellows five or six feet long were secured and safely placed in the large pond, that was fed from the Hudson River.

At first the new-comers created a terrible commotion. The water became muddy and was in a

their rough heads, with two traces leading behind. The bridle was a similar loop of canvas that fitted over the head, and to it the reins were attached.

A boat was floated over a sleeping fish, then a man leaned carefully over and dropped the loops directly in front of the fish and over its head. The sturgeon started forward and so made sure its capture, though there was a fierce struggle before it submitted to wear the harness.

When finally under control, it was secured with a harness that resembled a shawl-strap, made of two bands of canvas fastened together, one encircling the fish in front of the pectoral fins, the other two feet behind it. Rising from the connecting-bands was a loop into which was fastened the single trace, to which, again, was attached the rope of a light boat. For a rein a loop was fitted around the very long nose of the sturgeon.

It was only after a long struggle that the harness was placed upon the sea-horse, and then it started off so rapidly that the old gardener, who was acting as hostler, was fairly hauled into the



A SAILOR RIDING UPON THE GREAT SUNFISH.

muddy water, and away went the sturgeon, rushing around the lake in mad terror, finally turning back down, as if dead. But this was only a trick, as it soon revived, and was again secured. The traces were then fastened to a light raft, and, to the delight of the experimenter, off the fish started, carrying the raft about the pond at a very lively rate of speed.

This practice was kept up for a number of days, until the sturgeon was so thoroughly tamed that it moved slowly along without attempting to run away. Its mate was now taken in hand, and after a similar schooling was completely subdued, and then fastened to the other. A light boat in imitation of a swan now replaced the raft, and in it the owner, who was a portly old gentleman, one day took his seat and the reins, and was soon speeding around the pond after two steeds that were, certainly, the strangest that ever were trained.

For some time the sturgeons were used in this way, finally dying, I believe, from some poison that destroyed all the inhabitants of the fish-pond.

I once kept a great shark in a tide-water aquarium on the Florida reef. Another shark, not quite so large, was used by myself and some young companions in a singular way. The first shark was a so-called "man-eater," an enormous creature so far as bulk was concerned, and one that had towed the fishermen's boat a long distance before it was overcome. The second was the kind called a "nurse," dark brown in color, large and prone to lie on the bottom of the sea as if asleep.

With no little difficulty we caught the nurse, towed it to the aquarium, which was an inclosed moat half a mile long, fifty feet wide, and from six to eight feet deep. It required a dozen or

more men to haul the fish, which was eleven feet in length, over the little tide-gate. Just before it was released a rope bridle was passed over it—a loop that fitted over the head and was tightened just behind the fins, so that it remained in place, a perfect saddle-girth. To this a rope about ten feet long was attached, and in turn made fast to a float. All this was prepared in advance, and it did not require much time to attach it, though the plunges of the shark knocked several men from their feet. Finally all was ready, and the shark was rolled over into the moat, where it went dashing away, the telltale float following at the surface.

For some time we had been engaged in building a boat which was to be the carriage of this steed. The masons had given us the frame of a great brick arch upon which they were working. This resembled a scow with square ends. It was a perfect skiff, except that the planks were an inch apart; but we filled these crevices and calked it with oakum. The day before the shark was caught, the boat was launched and tested, and it was found that it would hold three boys, two on a lower seat and one on the box-seat of the coach. The "shark ride" was looked forward to with the greatest interest.

Finally the day arrived, and very early, while the great tropical sun was creeping up through the vermilion clouds, we made our way around the wall and to our marine carriage. Being the originator of the scheme, the privilege of the box-seat was awarded to me. Literally this seat was a box—a discarded cracker-box. My two companions sat upon a board in the stern to balance the skiff. We were soon in place, and sitting on the box, I carefully paddled the little craft out from the tide-gate, and began the search for our steed. I paddled down one side of the great wall, keeping perfectly quiet, as every quick movement threatened us with a capsize.

Presently we saw the float lying motionless on the water near the wall. The shark was undoubtedly asleep, little suspecting the rude awakening that was in store for him. I now handed the paddle to one of the boys behind me, and took in hand our painter. The latter is the rope fastened to the boat, and it was now my business to secure this to the float and to arouse the shark.

One of my companions paddled gently, and the flat-bottomed boat slowly drifted on. Leaning forward, I picked up the float, and quickly ran the painter through a hole that had been left in the float for the purpose, and fastened it with a bowline knot in a very seamanlike manner. When

this was done, I hauled in the slack and gently pulled the rein, while one of the boys "clucked" at the shark, and the other said, "Gedap!" No response. Then I gave another jerk at the line, and the shark woke up.

I have often read of boys who awake at sunrise and bound out of bed with a single leap, and have always thought that such sudden awakening could be true only in books. But that was exactly how this shark woke. It fairly leaped out of a sound sleep, and jerked the skiff ahead so violently that the box-seat upset and I fell backward upon my companions. This upset was certainly not a dignified beginning, and I heard a roar of laughter from some fun-loving lookers-on.

The shark, now feeling the rope, dashed along at a rapid pace, making it extremely difficult for us to retain our places; but my companions aided me. Carefully raising me, they righted the box. I secured the painter and held the single rein in triumph. It was a signal success. We had harnessed the shark, and were moving at a rate that was wildly exciting. The speed was so great that the boat was pulled almost bow under, and a wave of foam preceded us. The boys held on tightly, but occasionally raised one hand and waved their hats and cheered when a head appeared at a porthole of the fort.

In the excitement of our start we had failed to notice that we were headed for the tide-gate, and that a turn must soon be made. And here let me say, for the benefit of any readers who may desire to drive a shark in harness, that they must never fasten the rein or trace or line to the boat if it is a small one. Tie it to an oar or to some float that can be cast off if occasion requires. Neglect of this rule was the cause of our downfall. The shark rapidly drew near the tide-fence where it must turn, and, at the rate of speed we were traveling, to turn without an accident was impossible. We saw this fact all at once, and then some one cried, "Cast off the rope!"

This was easier to say than to do, and I pulled until my arms ached, but could not gain any slack from the shark; then I passed the rope astern, and our six arms pulled with all their strength.

How this might have resulted is a question; but at that moment our "fiery" and certainly "untamed" steed sighted the dam, and turned like a jack-rabbit, whirling so suddenly that I seemed to fly off into the air with the box-seat. My companions, who had been holding to the rail with grim determination, fared a little better, and almost survived the turn. But as the shark started ahead on the return journey, it jerked the craft so violently that it seemed to shoot into the

air, and as I was swimming with the box-seat, I saw the bare legs of the other two boys for one fleeting moment in the air, and then they were swallowed up, the kindly waves shutting out the derisive laughter of the observers. We soon swam to the tide-gate, and climbed upon the seawall. Then we ran along to see the shark towing



"A BOY RIDES ONE OF THE BIRDS BAREBACK."

our coach. It now skimmed along the surface this way and that, but without upsetting, illustrating that, despite our accident, shark-driving might be a success if the matter was properly managed.

Years ago, when Barnum, the great showman, was in his prime, he kept a white whale in a large tank. This animal became so docile that it readily submitted to the harnessing process. From the harness traces extended backward, and were fastened to a boat. Children—two or three at a time—sat in this boat, and were towed about the tank behind this strange steed. The whale would occasionally come to the surface to blow, raising its small eyes out of water and gazing at the boat and its occupants in probable amazement; but it never attempted to "run away" or leap out of water, as whales sometimes do, being really one of the most docile of all the strange steeds about which it has been my good fortune to know.

Not a few of the old whalers can relate marvelous and true stories of rides taken entirely against their will, large whales often towing their boats for many miles at frightful speed. On one occasion a whale was struck in the North Pacific, and immediately dived—"sounding," the whalers call it—directly to the bottom. The line whizzed

out so rapidly that it smoked from the rubbing; but suddenly it stopped running, and there was a threatening silence. "She's coming up!" cried one of the men. The oarsman shouted, "Stern all!" But it was too late. The maddened whale came up like a shot, and sent the boat, crew, and oars flying twelve or fifteen feet into the air. In coming down one of the men fell upon the whale's back as it started away, rushing along at the surface of the water. The harpoon was still sticking in the animal, and, seizing it, the man held on for several moments, and was carried along bareback; but the big waves created by this method of traveling were too heavy, so he was soon washed off, and was picked up by another boat from the ship, the crew of which had been astonished spectators of the strange performance.

In certain South American rivers and their tributaries is found an enormous fish called the *Studis*. It often exceeds twelve feet in length, and is one of the heaviest fishes known, even the scales being seemingly carved bone. Though large and powerful, it is extremely sluggish and fond of lying in shoal water, and on this account can be hunted by the natives, who shoot it with the bow and arrow, or spear it with an iron-tipped bamboo rod.

Once a native in the bow of a boat raised his spear and struck it violently into the head of one of these great fishes. The fish, probably asleep, feeling the spear, dashed fairly out of water with a tremendous leap, producing a ludicrous result. The spearsman was lifted clear of the boat. Before he was aware what had happened, he found himself astride the monster's back and flying away through the water. The fish could not dive, as the water was too shoal, so it rushed away, followed by a cloud of flying foam that almost buried the rider. The man convulsively clung to his spear, leaning back to avoid the waves, and presenting a laughable spectacle to his comrades. The race, however, was short. The fish made for deep water, and dived, forcing its rider to relinquish his hold so as not to be carried under, and to swim toward the following boat.

The porpoise could easily be trained to tow a boat, and probably a number of the larger marine

fishes would yield to patient treatment. Swans have been harnessed to boats; and the great albatross has been known to save the lives of persons falling overboard at sea; the swimmer, happening to grasp its dangling webbed feet, has been supported on top of the water till rescue came.

An adventurous planter in Florida some years ago attempted the education of an alligator. This proved, however, impossible.

When the alligator had reached the length of twelve or fifteen feet, the idea of training him occurred to the owner, and was immediately tried. Long ago the alligator had been a household pet, but had outgrown this condition, and lived near the boat-house among the reeds and rushes, occasionally crawling up toward the house for food.

For some distance offshore there extended a shallow flat, and getting into a flat-bottomed boat one day, the planter, with a colored boy carrying several fish, shoved off, followed by the harmless reptile. A rude harness had been made, and was easily slipped over its head. Then, instead of giving the fish to the alligator, the colored boy struck the waiting animal over the back with the oar. For a moment the reptile seemed paralyzed with astonishment; then, suddenly feeling the extent of the wrong, it rushed off in a floundering manner. The dandy was clinging to the reins and shouting with glee, while the planter picked himself up from the bottom of the boat, where he had been thrown at the first start of the strange "horse."

Contrary to their wishes, the alligator did not move out toward the open flat, but, turning quickly toward shore, it rushed in, and, with a few strong lashes of its tail, landed on a mud bank, the skiff grounding with a shock that again threw the planter over. Jerking the reins from the driver, the alligator scrambled over the bank, leaving the voyagers hard and fast. Thereafter the alligator was allowed to remain quiet in its muddy home.

Among land animals, the deer is harnessed in some countries, while the reindeer, yak, Cape buffalo, and camel are of great use to the people of the countries in which they live.

STRANGE ANIMALS THAT NEVER EXISTED

A CLEVER man has been writing about the intelligence of animals, saying that we give them credit for far more sense than they possess. How can we believe the horse to possess much sense, he asks, when, after the thousands of years that it

has been domesticated, it still shies at a white stone on the road, or runs away at the sight and sound of a steam-engine or motor-car?

That seems very hard to answer. When we come to think it over, however, while we cannot

but regret that some horses should still do these stupid things, we have to remember that the human race has not always been as wise as it is to-day. We know that men have believed things quite as absurd as what the horse believes when it sees something unusual on the road. The horse is descended from a wild animal which learned that by a sudden rearing and swerving it could avoid the attack of enemies hidden in the long grass or bushes waiting to attack it, so to-day, when taken by surprise, it still shies on the road, because its instinct of fear and desire to avoid danger are not dead. Its instinct overmasters its reasoning powers.

SOME STRANGE BELIEFS OF SAVAGES

SAVAGES have most extraordinary beliefs. They worship everything that frightens or puzzles them. In parts of India they worship plague and cholera. One African tribe worshiped the bottles which had contained the medicine that cured them of illness. But, wild as are the beliefs of the savages of our own day, they are not more absurd than the beliefs which our ancestors held, even in days of learning. We can laugh at these beliefs now, but we can also get some instruction out of them, and wonder how some of the strange ideas arose. We must not forget that our ancestors believed in magic, and nothing seemed impossible to their minds. They thought that the toad had a precious stone in its head, and that this stone could be used as a charm to cure sickness. Hence so-called toad-stones became common.

THE MARVELOUS UNICORN AND ITS MAGICAL HORN

HALF the animals that never existed were supposed to have magic powers. Thus the unicorn, which figures in the national arms of England, was believed to possess magic in its horn. Men were supposed to go on long pilgrimages in search of this animal, which was said to roam in India, Arabia, and Morocco. No man arrayed as a man could approach it. He had to disguise himself in the dress of a young girl, perfume his clothes, and lie down in the haunts of the unicorn. The unicorn, attracted by the scent upon the hunter's dress, would then approach, and, charmed with the sweet odor, would lay his head in the supposed maiden's lap, and fall asleep. Thereupon the hunter had to grasp the horn, and, with a single powerful wrench, pull it out! Or, if that were too bold a course for one man, then, while the disguised hunter lured the unicorn to

him, others lay in hiding and dashed up to seize the coveted horn as soon as the beast slept.

How men managed to impose this story upon their hearers, and at the same time make them believe that the unicorn was so savage that no man dare approach it, is not for us to decide. They were bold enough to tell the tale and actually to produce what they called the "horn of the unicorn." A writer of the time of Queen Elizabeth mentioned one which he saw at the Queen's court. It was worth a fabulous sum, he said. What really was this unicorn's horn? It was the spiral horn, or tusk, of our old friend the narwhal! The rhinoceros was supposed to possess something of the qualities of the unicorn, and brave Marco Polo, the traveler, while giving an excellent description of the beast, said that it did no harm with its horn, but with a fearful tongue, all covered with prickles, it rasped the flesh off its victim's bones!

THE DEADLY DRAGON AND THE BALEFUL BASILISK

How did men get their idea of winged dragons? There really were, once upon a time, creatures in some ways resembling the things which the frightened imaginations of men pictured. But those that actually lived belonged to the age of great reptiles, and there were no men alive to know of them. The fact that these creatures had existed was not known to the world until long after men had ceased to believe in dragons. All sorts of terrors were supposed to result from the dragons, which were believed to poison all the places over which they flew. As the unicorn and the rhinoceros were said to free the waters from the poison of the dragons, we have another reason why these animals were held in such respect.

But our ancestors did not waste all their fright over the dragons; they believed that the basilisk was a brute still more to be feared. This reptile, which was considered the king of its order, was supposed to be hatched by a serpent from the egg of a cockerel, and the cockerel was the only creature of which it was afraid. A glance of the basilisk's terrible eye was said to kill a man, while the creature was supposed to be so charged with poison that it infected the air, so that all living things, plants, herbs, beasts, and birds, fell dead wherever it went. We can see for ourselves what this frightful monster really was, for it was nothing more nor less than the innocent basilisk of our time, a lizard living upon little insects and small creatures frequenting the water and foliage in which it lived.

STRANGE TALES OF SATYRS, SPHINXES, AND GRIFFINS

THAT gives us an idea of the power which our ancestors had of frightening themselves over innocent animals. They believed that there were creatures called satyrs, which had the head, horns, legs, and feet of goats and the bodies of men. Then there were all manner of dreadful stories of hairy men with tails, which we know now were distorted accounts of the great apes. Every child to-day is familiar with the idea of the sphinx; but when we speak of the sphinx we think of that great image in the sands of Egypt. In the old days, however, the sphinx was a thing of real terror to men. They thought of it as an actual living creature—an animal with a human head and face, the body of a lion, the wings of a giant bird, and the tail of a dragon. But the griffin was still more to be feared. This was a creature which had the head and neck of an eagle, a hundred times enlarged, and the body of a lion, eight times as big as that of an ordinary lion. His talons were said to be as long as the horns of an ox, while his bones were so great that his ribs made bows for the stoutest warriors. Need we wonder, then, that the monster*bird-animal could carry off to his nest a horse with a man upon its back, or two oxen yoked together at the plow? No wonder, if this monster was believed in in Europe, that the Eastern peoples believed in the giant bird, the roc, which was said to fly away with human beings in the well-known "Arabian Nights."

THE BRILLIANT PHŒNIX AND THE WOLF-MEN

THEN we must not forget the phoenix. This was a marvelous bird, sacred to the sun. It was as big as an eagle, with brilliant golden plumage round its neck, while the rest of the body was of a purple color. The tail was composed of long and brilliantly colored feathers. Here, undoubtedly, we have the golden pheasant, which we may see any day in New York at the Zoo. It is not as big as an eagle; it does not rise alive from its own dead body; it does not live 540 years—all of which was believed. But otherwise it answers the description which old naturalists gave of it. They undoubtedly did see a golden pheasant, then very rare in Europe, and, of course, they had to weave a tale of marvel and magic and mystery round it. That was their way.

They invented marvelous stories about the fox, the wolf, the hyena, the lion, and other animals.

Men were sometimes supposed to be turned into wolves, and these "wolves" were thought to be far more fierce than the ordinary beast of prey. That is one of the ideas which has lasted. Natives in India still believe that men are turned into tigers, and the natives of Australia imagine that they themselves are inhabited by the spirit of an animal, a tree, or a plant. The same strange ideas are to be found among the savages of Africa. The faith which our ancestors held in these matters in the Middle Ages was very much like the faith of the savage people of the world to-day.

How firmly the old beliefs were held we may know from certain expressions commonly used to-day. We still speak of a movement which has seen evil days, and comes again to prosperity, as "rising, phoenix-like, from its ashes." We still speak of persons who like the heat of the fire as "salamanders," because the salamander was believed to live upon fire. We still use the word "gorgon" as a term of terror and horror.

"GORGONS AND HYDRAS AND CHIMERAS DIRE"

THERE was an ancient gorgon and a modern one. The ancients had their gorgons, monsters whose heads were clad with serpents instead of hair. But our later ancestors had a gorgon of quite another kind. Their gorgon was a fearful creature living in Africa. It had the body of what we might call a giant armadillo, with an impossible serpent-like tail, the legs and feet of a pig, and armed with great scales. The head was a masterpiece of imagination, a sort of ox's head, covered with coarse hair. But the eyes and the breath were the things! Men were not quite sure which did the damage, but either the breath or the eyes, they said, sent forth poison which instantly killed men or animals who might attack or even approach the gorgon.

Even a child can laugh to-day at the ridiculous things which frightened the wits out of the great scholars and philosophers of long ago. We might not be so amused if our ancestors had merely believed in these things, as silly people in our own day believe in ghosts and witches; but they wrote solemn books describing terrible adventures with these imaginary creatures. The list of impossible things in which people believed in those far-away ages is almost endless. There was a certain sort of lamb which grew on a tree. There was a tree which grew out of the sea from the timber of wrecked ships and produced geese. There was a frightful thing called the chimera, an awful crea-

ture with three heads—those of a lion, a goat, and a dragon. There were fabulous creatures called harpies and sirens—we still use the names in ordinary conversation and writing to-day—which drew seamen to destruction. The harpy had a woman's face and body, but the talons of an eagle. The siren we know to-day is a terrible screeching thing used by motorists to wake sleepy drivers on the road, or by steamers at sea in a fog; but the sirens of old were supposed to have lovely voices, which drew navigators from their course at sea, and lured them on to rocks from which there was no escape.

SOME SEA-MONSTERS THAT REALLY EXIST

WE need not be surprised that the sea gave our ancestors good scope for nightmare stories in which they could all believe. Even to this day, the vast, mysterious ocean has a fascination and terror which never grow less. We all know the sea-lion, which is simply a big seal. But it used to be considered a monster of the deep like a real lion, clad in mail. The idea must have come from some observer noticing that this seal, when dry, shows a sort of mane, giving it rather a lion-like look. Then somebody who had never seen one would argue from this description that the sea really had a lion, and would add the coat of mail as an ornament to his story. We have also the sea-elephant, a huge, queer-looking seal, with a snout something like a small elephant's trunk. That was observed long ago, so men wrote about a sea-elephant, and drew pictures of it, making it appear that the animal truly had the head, trunk, tusks, and front legs of an elephant, the hind quarters being simply the body of a fish.

Their descriptions of the whale were as amazing as any. The size and strength of this huge beast should be enough to satisfy anybody, but it was not enough for our ancestors. They described it as being about 960 feet long and 480 feet broad. The teeth were said to be 12 feet in length, and the eyes were so big that twenty men could sit in the space of one!

The whale was said to have two horns, or tubes, through which it sent great columns of water powerful enough to sink any ship. As if that were not enough, the whale was declared to rise above the clouds and, descending upon the ship, sink it in that manner! Furthermore, its head was armed with a great number of prickly horns. We can see here, through the exaggeration, that some one had tried to describe a toothed whale, but the idea of the horns about the head had arisen from the plates of baleen in the mouth of

the whalebone whale. This monster was said to come up to the surface of the water, bearing quantities of sand upon its back. Sailors would approach in their ships, and, mistaking it for an island, would cast anchor in its back, land, and make a fire on it to cook their meals, until the whale, gradually feeling the heat of the fire, would dart down into the sea, carrying men and ship with it. But the imagination of the early traveler was by no means exhausted when he had finished telling the harrowing tale of the whale.

THE CRUEL KRAKEN AND ITS WICKED WAYS

THERE remained the kraken to describe. Now, the kraken was the most terrible of sea-beasts. There were supposed to be sea-bishops and sea-monks who did all sorts of alarming things for the terrifying of unhappy mariners, but the kraken was the worst of all. It was a creature whose back measured a mile and a half in circumference, so that, as it floated on the crest of the waves, sailors mistook it, as they mistook the whale, for an island. But the kraken had arms like the tallest masts of ships, and with these it could seize the greatest vessel and pull it down beneath the waves. When the kraken sank, it was supposed to create such a whirlpool that all ships near were sucked under, and their crews drowned. It was a Norwegian bishop who first spread the story of this monster. There can be no doubt that he really did see a very large cuttlefish. Nobody knows how big the biggest of these really is, but we know that its body is nothing like what the frightened bishop thought he saw, nor are its arms capable of upsetting a ship. The stories of the kraken grew rapidly, but they became mixed up with stories of the sea-serpent, of which the most fanciful tales were told. There *may* be a sea-serpent, but, so far, no story which has ever been tested has managed to stand unshaken. Ribbon-fishes have been mistaken for sea-serpents, a line of whales with peculiarly shaped backs has had the same effect, and many other curious sights seen in brief snatches at sea have misled men into telling the same old story. Sea-serpents are reported nearly every year, but—well, they always end in a *but*!

SOME BEAUTIFUL SEA-CREATURES THAT LIVE ONLY IN POEMS

THEN there were the mermaids and the mermen. That was an old belief, and to-day many people believe still that these creatures of fancy actually exist. Poets have helped to keep the be-

lief alive, and Matthew Arnold wrote a lovely poem on the subject. The mermaids were supposed to be beautiful women having the tails of fishes, and the mermen were the male members of the family. The whole idea is charming, but the reality is sadly disappointing. The mermaids and their lords are only manatees and dugongs, or sea-cows. All the mermaids of our poems and stories are lovely in feature, but the animals themselves are rather hideous, and dull, stupid things, too. They are about ten feet long, with curious fleshy muzzles ending in a sort of disk. The great virtue of the mother manatee or dugong is her love for her little one. She tends it with all the care and affection possible. When she feeds it, she raises herself in the water, clasps the little

one to her, holding it with one flipper, while she swims with the other. Thus, at a distance, a sailor might imagine the pair to be a mother and child in the water. The legend as to the streaming hair could scarcely come from the bristles with which her head and face are surrounded. The manatees and dugongs live on seaweed, and no doubt observers thought that this seaweed was mermaid's hair. One kind of merman was called a sea-bishop, because it was supposed to have a miter-shaped head.

The list of absurd things in which our forefathers believed is not nearly exhausted, but those which we have described help us to understand the strange world of thought and fancy in which they lived.

AN ODD PRACTICE OF THE MALABAR SQUIRREL

THIS squirrel in the illustration was not playing ball; he was eating an apple. You should have seen how dexterously he cast away the skin, bit by bit, as he rapidly turned the apple about, engaging his chisel-like teeth in it.

There was another one of them perched on the same rung, on the other side of the pole, eating his apple, and facing the same way as this one. They retained this position for about eight minutes, I should say, and then I had to wait for some time before one took it again. After eating about half their apples they dropped them on the floor of the cage, and later, when they wanted to try another bit, returned with the apple—what was left of it—to this queer attitude on the perch. I suppose they eat heavy fruits in their native trees in just this same fashion.

These are Malabar squirrels from India, south of the Ganges River. They live in the highest forest trees, seldom coming to the ground. They are very much larger than our common gray squirrel, and much more beautiful in coloring. From nose to root of tail they measure about twelve inches, and the tail adds about sixteen or eighteen inches more. The darkest parts are glossy black; the lighter part, over the back and sides, is a beautiful, rich maroon. The face is dark yellow, with black on its top, while the under parts and fore and hind feet are a lemon yellow.

Notice the enormous muscular development of the forearms, showing what a life in the tree branches has done for this lively animal. The large cheeks also show what powerful muscles are provided to manipulate those keen, chisel-like

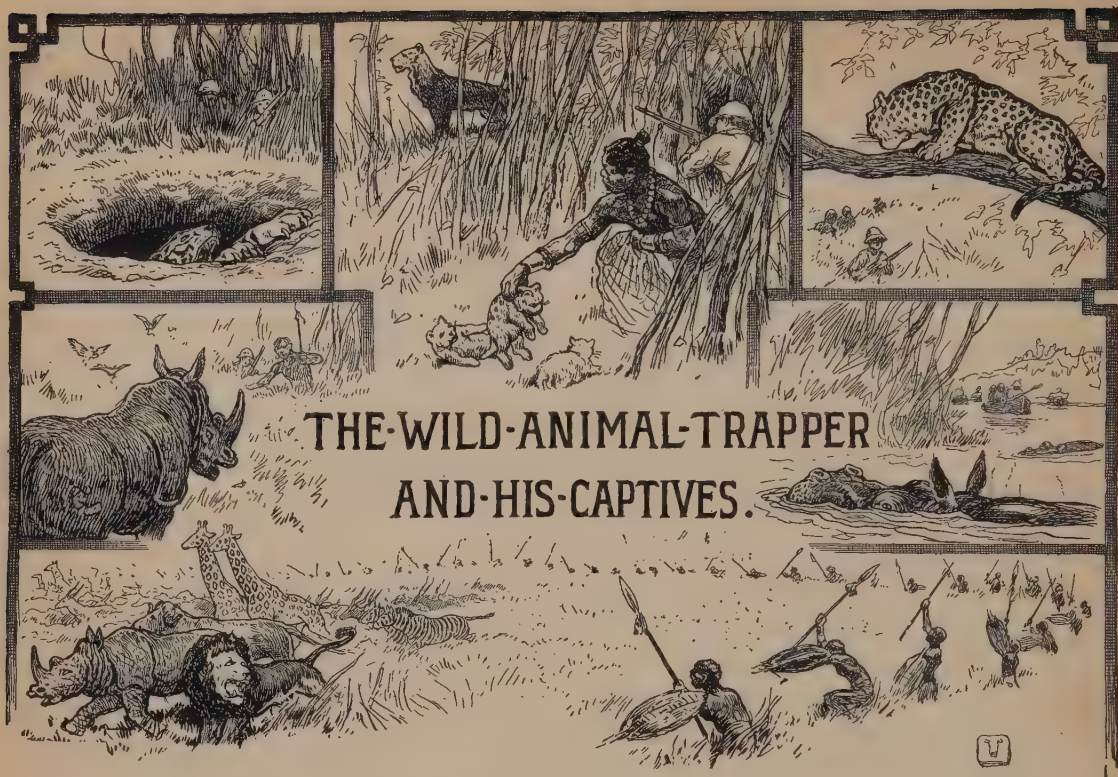
teeth, which can cut right into a nut of almost adamant hardness.

Had not nature provided him with a long,



THE MALABAR SQUIRREL EATING AN APPLE.

heavy tail, he would have to select some other way than this to eat his apples. It probably would not tax his brain very much beyond its power to find a way!



BY A. W. ROLKER



THE wild-animal trapper of to-day has invented his own methods for catching ferocious beasts, and has systematized and perfected his work so well that if the animal you want is on the face of the earth, the trapper will get it for you. At the head of an army of two thousand or three thousand he may march deep into a jungle, surround ten or

twelve square miles of wilderness with a human net, and drive hundreds upon hundreds of lions, tigers, buffaloes, zebras, deer, and scores of other species of beasts, fleeing panic-stricken before him, into a stockade. Or, with a mere handful of Kafirs, he may march into a wilderness where no human foot ever stood before, to be swallowed up for one, two, or even three years while he hunts and traps a rare, unwieldy pachyderm like a black rhinoceros, and transports it a thousand miles back to the coast.

Strange as it may seem, the easiest victims of the wild-animal trapper are the most ferocious—

those bloodthirsty, huge cats, the lion and the tiger; and those other beautiful felines, the panther, the leopard, and the jaguar.

With the lion, for instance, it is simply a matter of stealing the cubs. But kidnapping her whelps from a dangerous beast like a lioness, is, of course, an exciting problem.

In the heart of the darkest, most impenetrable thicket, in the midst of a tangle of vine and thorn and creeper, the lion mother has with her from four to six cubs—golden puffballs—tumbling over one another, scrambling over the great yellow body of the majestic creature which none on earth save these defenseless kittens may approach.

Not in the wide world, it would seem, was a home better protected. Yet, out of a thicket, well to leeward, the trapper's eyes are bent upon the lion home—for, once in every twenty-four hours, Nature herself renders these babies defenseless, when the mother, stirred by the pangs of hunger, ventures forth to hunt and to eat.

Beside the trapper is a pair of Kafirs armed with nets made of stout cords. In the trapper's hand is a rifle loaded with a slug of lead as big as a little finger. The slightest snapping of a twig, and the dangerous brute comes to the attack head-



long, like a yellow streak; or, if she cannot locate the danger, she picks up her cubs one by one by the neck, bounding away with them in ten-foot springs and hiding them in a tangle even more dense than the other.

For hours the trapper must lie, nerves on edge, before the mother quits her lair to strike down a buck or a water-buffalo. Then, cautiously, with rifle ready, the trapper presses forward and into the unguarded lion home.

Quickly the men must work. Should the lioness return unexpectedly, nothing but a bullet well and quickly aimed could save them.

Capturing cubs is, however, only one of three methods which the trapper uses to transfer the big felines out of the wilderness into his cage. By far the greater number of his captives are adult beasts in the height of their prime, vigor, and ferociousness. To catch these, the trapper uses either a pitfall or a huge trap.

The best illustration of outwitting these sly, cunning creatures with so simple a contrivance as a hole in the ground is in the case of the tiger, that magnificent orange-and-black-striped creature of herculean strength and serpentine grace, who can break the spine of a bullock with a single blow of his paw or can hurl himself to the forehead of the tallest elephant. True, he does not always come out victorious in the encounter with that burly antagonist; but, while as strong as the lion, the tiger surpasses the majestic king of beasts in agility, daring, and ferociousness. And when once he has turned man-eater, he loses the last vestige of fear, and stalks a man as if he were a beast of the field.

To enter a forest, trap one of these fearless animals, put him in a traveling-cage, and load him on a bullock-cart, seems like an almost impossible feat. To the trapper, who simply takes advantage of the brute's savage instincts, few animals are more easily captured.

Within the district haunted by the tiger, the trapper prospects along the game-trails, for the tiger is a lazy beast that spurns a chase and hunts by lying in thickets along these trails, springing on his prey while it is on the way to drink. With rifle across his knees, to guard against a surprise,

the trapper sits while two men dig a bottle-shaped hole ten feet deep, nine feet wide at the bottom and seven feet across at the top. A native weaves a stout lid of bamboo and cane to cover the mouth of the excavation, and when the lid is in place procures a young goat and ties it to the center of the lid. For as the poor worm or the poor little fish has to serve as bait for the larger fish, so with the capture of these big beasts.

When the tiger leaps, it is to his own undoing; for this time there is a crash of splintering bamboo, and out of the earth which has swallowed the monster form comes the cry of a crazed tiger fighting for his liberty.

Unable to understand what has happened, the frenzied brute, hurled with the tremendous impact of his own vicious spring into utter darkness, rolls over and over, biting, snarling, ripping and tearing at the strips of bamboo that prod and stick him in a score of places. The terror of this mysterious enemy assailing him in the darkness drives the brute frantic.

With the coming of the day he tries to spring out. Crouching low, he aims for the top, hurling himself with every ounce of strength pent up in his wonderful frame. The great paws reach the brim of the hole and slash the ground in a vain effort to take hold; but against the sloping sides of the pit even the amazing agility of the tiger is helpless, and his struggles only bring down show-ers of dirt.

Now comes what seems the most difficult part of the capture—to go down in the hole and bring this fierce cat out into daylight. But again the trapper resorts to a ruse. He takes a net of rattan rope six or seven feet square and with meshes four or five inches square, and he drops this, spread, on top of the tiger. Not in the lifetime of the forbidding beast has anything save blade or twig touched the beautiful skin, and contact with this new mysterious object, which in fact covers his whole body, at once robs him of all reason. Fighting as never before, he tries to rend the intruder to pieces; but one by one his paws become enmeshed and entangled. The more they are entangled the more fiercely he fights, and the more fiercely he fights the more they become en-





tangled, until at last the creature, thoroughly exhausted, has tied himself up helplessly, a mere heap of helpless fury.

Then the trapper goes into the hole and fastens a rope to the net, while natives haul the prisoner into daylight. And soon the big, gorgeously beautiful beast is picked up and placed in a narrow cage loaded on a cart. The trapper reaches through the bars and carefully cuts the net in places so that the animal can struggle and gradually free himself inside the cage; and, when once released from the bamboo net, away he goes to the coast, to the wild-animal mart.

Often during a wet season or in low ground a pitfall is impracticable, because it would fill partly with water, and a beast falling into it would drown and be lost to the trapper in this way. Under these conditions the expert builds a contrivance which is simply an enormous live-rat trap, the sort used exclusively in taking those less powerful and yet equally stealthy and treacherous creatures—the panther, sleek and glossy, night-black and yellow-eyed; the leopard, that beautifully skinned yellow-and-black-spotted marauder of darkness; and the jaguar, half-brother to the leopard, orange-and-black-spotted, the “tiger” of the South American jungle.

Less formidable than the lion or the tiger, what the jaguar loses in size and strength he makes up in lightning swiftness. Contrary to general opinion, this creature will not attack a man unless he is cornered or driven to desperation. But of infinite cunning is this beast. It is the stealth and the cat-like cautiousness that make the jaguar so difficult to trap.

The best time to locate the jaguar is during the dry season, when the rain falls not for three months, when the jungle shrivels up to brown tinder, when springs and streams are dried to dust, and when the biggest rivers shrink to streams you could wade across. Then game comes from hundreds of miles from the interior to drink at the fallen rivers, and then, also, the jaguar comes forth.

Cutting saplings five or six feet long, thick as a forearm, the trapper sharpens these at one end and drives them into the ground side by side,

forming the three sides of a stout cage which, when provided with a similarly stout roof and with a trap-door at the fourth side, is a cage just about big enough for the jaguar to stand in.

The trapper baits the trap with some small live animal in such a manner that when the jaguar seizes it the trap-door, weighted with three hundred pounds of rocks, falls shut and holds the big cat prisoner.

Invariably, the jaguar seeks his prey under cover of darkness. Cat-like, when he sees the trap, he hesitates. Distrustfully he walks around and around the trap, squinting out of narrow yellow eyes at the bait within. Often he lies in front of the open door for some time, motionless as a log. What troubles him is not so much the trap itself as the suspicious human scent clinging about it. But gradually his appetite sharpens. Nearer and nearer he inches toward the opening, until it seems to him that to dart in, grab the morsel, and dart out again must be, after all, a simple matter.

He crouches close in front of the open trap-door, twitching all over, switching his tail, and laying back his ears as if ready for unexpected trouble. A dart forward, a dull thud, as the heavy door falls, and—instantly the jaguar realizes he is trapped, and the jungle reëchoes with the cries and snarls of his maddened fury.

Next morning nothing remains for the trapper to do but to transfer the captive into a portable cage. This cage, provided with a sliding door, is opened and set and lashed against one side of the trap. Then the stakes between the trap and the open cage are raised. Like a shot out of a gun the jaguar darts within, and in a flash the sliding door of the cage is pushed shut. Then, with eyes gleaming, lips drawn back, there crouches the most treacherous, cunning, and naturally bloodthirsty of all the big cats—a life prisoner.

But trapping the big felines is child's play compared with the work of capturing those lumbering, colossal animals of the “big pig” family, the rhinoceros and the hippopotamus.

Too stupid to tame or to break to a halter, and too heavy to transport through hundreds of miles





"THE TIGER DOES NOT ALWAYS COME OUT VICTORIOUS IN THE ENCOUNTER."

of wilderness, it would take a man half a lifetime to bring one of these five-to-six-thousand-pound creatures out of a jungle into civilization. Therefore the expert's only chance is to find a cow with a calf and to capture the young one.

Compared with the alert, grim exterior of the felines, there is little in the appearance of a phlegmatic, ponderous pig like a rhinoceros to indicate its real ferociousness. There is hardly a wild animal in existence which is more dangerous than this rarest of all our menagerie captives. Awkward as the great creature appears when at rest,

during hardships and privations, until at last he arrives in the rhinoceros country. Skirting swamps and rivers, the men are ever on the lookout for the deep, round spoors, like a pie plate driven into the mud, for in this wet ground the rhinoceros loves to wallow. Frequently five or six months elapse before the tracks of a cow and a calf are picked up.

Noiseless and from well to leeward, the trapper and his men gradually steal nearer until the cow and the calf are inclosed in a circle. From ahead, out of the maze of cane and creeper, sounds the



"AT SIGHT OF ONE OF THE SAVAGES THE RHINOCEROS DASHES WITH THE SPEED OF A RACE-HORSE AT THE MAN."

once aroused it dashes through the densest thicket with the irresistible speed of an express-train.

To catch a rhinoceros, the trapper proceeds with preparations much as would an explorer bound for a two- or a three-year expedition into the interior of an unexplored continent; for the difficulty confronting him is the threefold one of first penetrating a thousand or more miles into the interior; secondly, of finding not only a rhinoceros, but a rhinoceros cow with a calf old enough to capture; and, lastly, of transporting his prize across hills and mountains and plains, over rivers and ravines, across swamps, and through forests, back to civilization.

With ten or twelve natives and a span of bullocks loaded with clothing, food, medicines, and ammunition, the trapper travels for months, en-

uneasy stamping of the cow. With a half-snort, half-grunt, in an instant the rhinoceros is all attention. Head raised and nostrils sniffing, she searches the air steadily. At sight of one of the savages the cow dashes with the speed of a race-horse at the man, charging the human decoy, and at that instant the trapper's rifle is heard, and her furious charge is over, provided the bullet reaches the heart, by striking just behind the left foreleg—the only vulnerable point in the inch-thick armor with which the beast is clad.

Now and then it happens that the trapper fails to kill in time—his gun may miss fire, intervening trees may interfere, or the marksman may miss his aim. Then the life of the decoy depends upon his own agility. To run to one side before the rhinoceros is almost on top of him would be fatal,

for the swift brute would overtake him with a few bounds. His only hope is to wait until the deadly horn is almost at his feet, and then, with the swiftness of a mongoose dodging the aim of a cobra, to leap to one side while the ponderous creature, unable to turn short in time, dashes onward under its own impetus. Twice, three times a clever native hunter will dodge in this way, giving the trapper ample time to bring down the rhinoceros.

Then comes the tracking of the frightened calf, which has fled at the first sign of trouble; and soon it is pushed, prodded, and shoved up a bridge of log skids into a cage of the bullock-cart.

But even more dangerous is the trapping of the hippopotamus. For although in itself the "rhino" is a more savage antagonist than the "river-horse," the trapper hunts the former on land and brings down at a safe distance, whereas in the case of the hippopotamus he must fight in the same primitive fashion that savages have used for ages. Hand to maw, as it were, he must engage this two-ton monster while standing in the bow of a frail canoe. For the hippopotamus, as its name, the "river-horse," means, is a land-and-water animal and must be harpooned and brought ashore before it expires, otherwise it would sink at once to the bottom of the river, the coveted calf escaping among the other hippopotami instead of following the stricken cow to shore, so that the youngster may be caught.

In the tank of a zoölogical park the fat, squat, lumpy-faced creature placidly munching hay in a yard-wide mouth does not appear to be the formidable antagonist she is when aroused in her own element in the wildernesses of Abyssinia. Yet, ungainly as the beast is on land, of all quadrupeds not another can begin to compete with her as a swimmer. Only a light canoe, propelled by the sturdy arms of a pair of expert paddlers, can hope to escape an infuriated "hippo." Should the men fail in escape, the penalty is dreadful. With one mighty upward toss of the ponderous head, the animal could send a canoe loaded with three men twenty feet high out of water.

From four to six canoes take part in a hippopotamus hunt. In the bow of one of these sits the trapper, holding a twelve-foot-long harpoon weighing forty pounds. In front of him lies a coil of line three hundred yards long and no thicker than a little finger. At the middle and at the stern of the canoe sit the paddlers, upon whom depends everything once the harpoon has been sunk.

Silently, without even the swish of a paddle, the trapper's canoe drifts down the river, leaving the other vessels fifty yards behind. From di-

rectly ahead is heard the splashing of the unsuspecting beasts, floating with heads sunk and gray backs barely out of the water, like so many islands.

Always drifting noiselessly, paddles immersed just enough to steer the canoe, the frail craft approaches. On the back of one of the cows stands what resembles a pink pig—a squat, lumpy-faced little calf, a funny little caricature of a hippopotamus, which, at sight of the strangers, disappears with a splash beneath the water. A sweep of the paddle, and the canoe heads for the mother of the calf. Should the big cow suddenly raise her head and discover the boat, she would give one horrible grunt and charge it, sending the hunters fleeing before her like chaff in a wind. As the canoe approaches, the trapper arises, steadies himself, poises the harpoon, gathers every ounce of strength within him, and, just as the nose of the vessel is about to touch the cow, thrusts the lance into the ponderous neck. There is an upheaval, a rush and a splash as if a volcano were breaking through the black waters, and above the seething foam arises a gigantic, ugly head.

Paddling madly, the three oarsmen send the frail vessel frantically through the water toward the shore, in the hope of fastening the end of the rope about a tree-trunk. But usually the attack is so vicious that the entire coil of rope fastened to a light float must be thrown overboard while the men flee. After the canoe darts the furious animal, chasing it clear to the shore. Then turning with a half-grunt, half-bellow, she heads for the very middle of the river, rising and diving, rising and diving, in a vain hunt for the hated human assailants.

For one or two hours the cow carries on this exhausting struggle before the men dare to venture on the water to pick up the end of the rope fastened to the float. Just as a savage bull may be led by one finger in the ring through his nose, so the exhausted cow now follows the tug of the light line, which is made fast about a tree, while black hands haul in the slack, the young hippopotamus following the larger animal to shore. A bullet from an elephant gun ends all unnecessary cruelty, and then the youngster, squealing, is carefully captured and loaded into a cage, to spend a life of ease and lazy luxury behind the steel bars of a menagerie tank.

Finally, trapping lions and tigers and rhinoceroses and hippopotami is only "retail business" compared with some of the "drives" the trapper conducts in Africa when he enlists the natives of villages for thirty miles around and traps lions, deers, elands, zebras, giraffes, buffaloes, and a dozen other species of beasts all at the same time.

One of these "drives" requires weeks of preparation. An enormous circular stockade is erected, a half-mile in diameter, ten feet high, and provided with a huge V-shaped entrance more than a mile across at the wide end.

Out into the jungle, ten or fifteen miles from this stockade, the trapper leads his army of two or three thousand men armed with shields and assagais. Like a spool of thread unwound, this skein of ebony warriors, the men marching thirty or forty feet apart, extends itself single file in a

rings from all sides at once, the beasts flee precipitately. Herds of the gaudy-striped zebra, of the graceful eland, and of long-necked, spotted giraffes flee panic-stricken for the life that is in them. The lion and his mate bound to their feet, sniff the air, and defiantly prepare for fight; but as the racket approaches they are seized with fear, and, turning tail, they bound away again. Even the rhinoceros, stupid though he is, sees the flight of the beasts surrounding him, catches the panic, and flees headlong without stopping to see



From the original etching by Herbert Dicksee.

IN THE ENEMY'S COUNTRY.

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straight line sixteen miles across the jungle, and at a stated time the line marches forward, the ends traveling quicker than the men at the center, thus forming a huge crescent, which sets up an ear-splitting din of yells and shouts, and with the clashing of spears and shields rushes forward toward the stockade like a gigantic human seine.

Through forest, across prairies of cane and grass, through swamps, and over hills and plains, the savages, lighted with the fever of the chase, rush wildly.

Within the gradually narrowing circle, panic-stricken at the mysterious unseen foe whose din

what is the trouble. The law of self-preservation is at work. Forgetful of small fears, of natural enemies and bitter enmities, the lion and the deer, the leopard and rhinoceros, and everything that creeps or crawls, run madly as if chased by a prairie fire.

Now and then a lion or a lioness, unused to long-distance running, becomes exhausted, turns on the pursuers, and springs upon a tormentor. Or a rhinoceros, blinded with terror and rage, turns and impales a savage and breaks through the lines. Or a buffalo comes bellowing, or a leopard springs. But these are trivial incidents in Africa,

where human life is the cheapest in the jungle.

The human gaps are closed up, the men drawing nearer and nearer each other as the crescent tightens while nearing the mouth of the V, amid a great yelling and clashing of spears.

At sight of the steadily narrowing V, the animals in front halt, suspecting the trap; but the beasts in the rear force those in front forward, while the white men's rifles and the redoubled yells of the savages send the last beasts into the stockade, the blacks, panting, bruised, and all but exhausted, leaping over the bodies of animals maimed or killed in the mad fight for safety.

In the old days the Kafirs simply turned loose, and after the trapper helped himself they killed and ate what beasts remained in the inclosure. But the modern trapper permits no such waste. He chooses for himself the finest specimens. Those maimed or injured he orders killed for use of the Kafirs, and he designates which of the other beasts captured they may take. The remaining animals, not just then needed, he prudently turns loose to increase and multiply in the wilderness—for to the wild-



"WITH ONE MIGHTY UPWARD TOSS OF THE PONDEROUS HEAD, THE ANIMAL COULD SEND A CANOE TWENTY FEET HIGH OUT OF THE WATER."

animal trapper of to-day the jungle is his own and multiply in the wilderness—for to the wild- , wild-animal farm.



"NEARER AND NEARER HE INCHES TOWARD THE OPENING."

THE TURTLE CIRCUS

If a turtle be carefully balanced on a spool, a slender bottle, or other support that cannot be reached by his legs, his swimming and walking



A TURTLE CAREFULLY BALANCED ON A SLENDER GLASS CUP.

movements may be easily studied. The vigorous manner in which the head is pushed forward, the eagerness with which the animal looks about, the frantic but unavailing strokes of the legs, are not only instructive but ludicrous, and one may easily compare such turtle-like characteristics

by arranging various kinds of turtles in what may be called an acrobatic row. Experiments by this method not only instruct and amuse, but have the advantage of not being injurious nor even painful to the victim. The turtle soon discovers that he cannot escape by reaching downward with his legs and then he tries to reach under. He will succeed in this effort unless the support is so slender that by the farthest in-reaching the "nails of the toes" cannot touch the support. If a pedestal of a proper size has been provided, and the turtle is well balanced, such efforts will not move him. His next attempt is to reach outward toward surrounding objects; and the experimenter must place his performers as a teacher of gymnastics places his; that is, so that by the most extended reach they cannot touch one another.

The wisest performers are the huge snapping-turtles, but these must be handled with care, because they bite fiercely. I have never known other common kinds to bite while being placed in position. To set a snapping-turtle in place, seize his tail with the left hand and elevate him to a vertical position. With a narrow board in the right hand lift the front end until it is hori-



A "TURTLE CIRCUS" BALANCING "ACT."

A variety of the smaller species of turtles. At the top of the right and left columns are the two youngest members of the "troupe" inverted.



THE JUMBO "ELEPHANTS" SHOW THEIR AGILITY!
These are huge snapping-turtles.

zontal, and while he is thus held, balance him carefully on a spool, a bottle, a long, slender glass tumbler, or on a goblet. If rightly placed, the snapping-turtle learns sooner than other forms that he cannot get away by reaching downward, under, or outward. Then he assumes a listless attitude that may be construed as resignation or as a pause for the inventing of new methods. I am inclined to think that he is not regarding the situation as hopeless, but is exercising his Yankee ingenuity, for my turtles are in the land of Yankeedom, all of whose inhabitants possess the ingenuity said to belong to "the wooden nutmeg State."

Some of the larger snapping-turtles in my vivaria soon learn to do, and to do well, all sorts of queer and surprising things. "Old Lineman" takes his name from the astonishing manner in which he climbs wire netting by thrusting his sharp "toe-nails" through the meshes, thus reminding the observer of the lineman who so rapidly walks up a vertical telegraph-pole.

"Old Lineman" has excelled all other performers in the "turtle circus" by learning a method of getting off the pedestal that is almost invariably successful. One day I placed above him another turtle on a spool, and he snapped so viciously and so violently (a snap that meant unmistakably, "I do not intend to be on neighborly terms with the tenant of the next spool story") that the shock upset the rather unsteady



FOUR "ATHLETES" (COMMON LAND TURTLES) INVERTED ON THE BACKS OF THE "ELEPHANTS."

support, and the whole came to the ground together. Here was a new experience, and the idea resulting therefrom was not lost.

I patiently started to repeat the experiment. I placed "Old Lineman" on the big spool. He hung down his legs as if he never expected to use them again. His whole attitude was as submissive as that of a kitten. He stretched his long head and neck as never before, and as I



AN "ATHLETE" (SNAPPING-TURTLE) RESTING
AFTER HIS CIRCUS "ACT."

reached down for another turtle, I congratulated myself that at last "Old Lineman" had become submissive to my will. But it was not submission, it was wisdom; for he suddenly gave an upward snap at nothing, as if there were a dozen annoying turtles above him, and that upset the careful balance, and—down he came!

He had learned a lesson by which he instantly profited every time I again placed him on the spool. And now the turtle circus mourns the absence of its biggest performer.

"Old Lineman" is too clever for it!

MOVING ON SHORT NOTICE

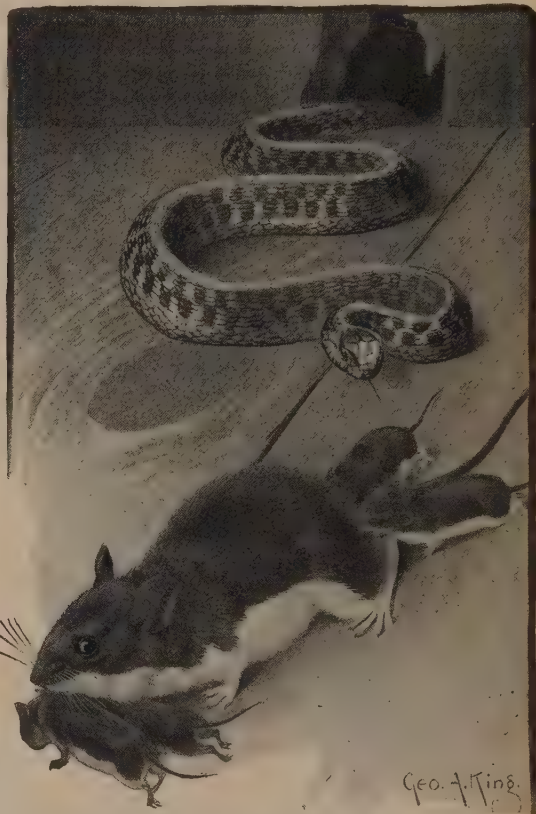
I WAS lying on the floor of an old country log-house one summer day, near a big, open fireplace, when I heard a peculiar, frightened squeak. I got up to see what looked like a huge mouse, moving at a very rapid walk across the room.

When I got a closer look I saw that it was a mother mouse moving her whole family. At least, I hope there was none left behind, for very soon a small snake, but large enough to put into a panic the mother of four less than half-grown children, came through the empty fireplace, and after the little fugitive.

The mother mouse had two in her mouth, and

fastened to either side of her, apparently holding on with their mouths and for "dear life," were the other two.

I killed the snake, and watched the moving family disappear through a hole in the corner.



"A MOTHER MOUSE MOVING HER WHOLE FAMILY."

I do not know whether they returned after a while, or whether the father mouse put up a "To Let" sign and joined them in a foreign country; but I do know that I saved a happy family.

ORIGINAL OWNERS OF OUR SEAL FURS

By F. A. LUCAS

THE first wearers of sealskin coats, which are of special interest in February and March, were, of course, the fur-seals; and as we usually think of furs in connection with snow and ice and cold weather generally, it may seem a little strange to learn that some seals should wear fur jackets directly under the burning sun of the equator. By far the best skins, however, and the greater number used for making cloaks, come from the Pribilof Islands in Bering Sea, and the Com-

mander Islands, off the coast of Kamchatka. Not very long ago, over one hundred thousand seals were killed on these islands each year; but, unfortunately, many are now killed at sea, and their numbers are growing less year by year. Still, enough are left to seem very many to one who

never saw the thousands upon thousands that once lived on these little islands, although if any one actually counts a great herd of seals, he will find that a thousand seals spread over the rocks make a great show.

One can get nearer to the home-life of these fur-seals than to that of any other wild animal, and by using a little caution, and taking care not to stand so as to show against the sky-line, it is quite possible to go within twenty or thirty feet of the fur-seal families, and to study them as well as if they were in the New York Zoo. Happy families they can scarcely be called; there is too much growling and quarreling among the big male seals for that. As for the females, they take life more easily, and, save for an occasional snap or snarl at one another, or at some strange little seal that has ventured too near, pass most of their time in sleep. Now and then they go off to sea for fifty, a hundred, or even a hundred and fifty



THE VERY RARE AND CURIOUSLY COLORED RIBBON-SEAL.

Only a very few of these seals have been discovered, and but little is known of their habits. On a smooth ground-color of either blackish brown or yellowish gray, it seems as if nature had sportively laid on some broad yellowish-white ribbons.



A GROUP OF THE ORDINARY FUR-SEALS.

"The original owners of our seal furs."

miles to catch fish, coming home in a week or so to care for their baby seals. Only one of these little fur-seals is shown in the picture, because when a few days old the little fur-seals move back from the ground occupied by the old seals, and there they stay for a month or so until they are ready to go into the water and learn to swim. When they have mastered this art they have fine times diving for stones and shells, sporting in the surf, or playing "king of the castle" on the rocks just off the shore; and when they are tired of this they come on shore and tear up the long ribbons of kelp, or climb up the rocky hillsides and hide in the nooks and crannies among the big boulders, or wrestle with one another, growling and biting in play just as the big seals growl and bite in deadly earnest. And after all this sport they curl themselves up by dozens and dozens and sleep. This is a pleasant part of a seal's life, but there is another side to it, when the young seals leave their island home and start south to pass the winter in the sea and get their own living. Just what happens to them we do not know, nor is it pleasant to think of; but of all the thousands that leave not more than half come back, and of all the fur-seals that are born probably less than one third live until they are large enough to be used for making cloaks.

THE LARGEST TURTLES

By F. A. LUCAS

THE boy who lives in the Eastern States would perhaps say that the largest he had ever seen was



THE COMMON SNAPPING-TURTLE.
Length, when full-grown, three feet.

a snapping-turtle three feet long, and the boy from Louisiana might reply that in the Red River there is a much larger kind, known as the alligator terrapin, sometimes nearly five feet in

length, and weighing 150 pounds. This seems pretty large, and it is large beside the little pond-turtles that are so familiar to us from their habit



VIEWING THE SKULL OF THE KANSAS FOSSIL ARCHELON.
Probable length of whole turtle, full-grown, twelve feet.

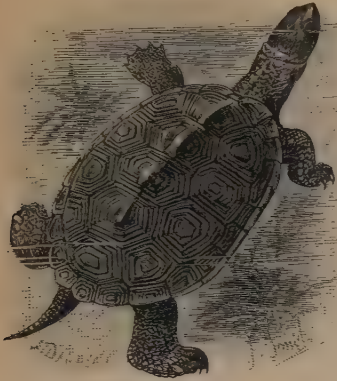
of crawling out on sticks and stones to bask in the sun; but the sea-turtles are very much larger—the green turtle, the kind that is used for making the famous turtle-soup, frequently reaching a weight of from 150 to 250 pounds, while its big-headed relative, well named the "loggerhead," sometimes turns the scales at 350, and now and then some giant is taken of nearly twice that weight. The largest of all sea-turtles now living is the trunk- or leather-turtle, for he weighs from 300 to 1000 pounds, and measures as much as six or seven feet in length, and seven or eight feet across the outstretched fore flippers. The name of leather-turtle is given to this species because the "shell," which bears five keels, or ridges, is not made of solid bone, but is a mosaic work of many irregular pieces embedded in a tough, leathery skin. Every summer a few of these big fellows are caught on our coast between Norfolk and Newport, having come northward in the warm waters



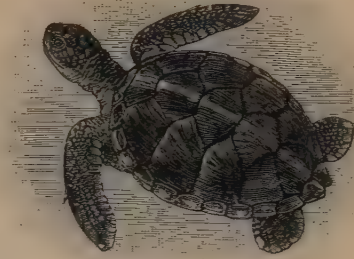
THE LEATHERBACK TURTLE.
Length, when full-grown, seven feet.

of the Gulf Stream. The flesh is said to be poisonous, so this great turtle is not so valuable as the others, which are used for food,

great-grandmothers, and nowadays made into pretty ornaments by skilled Japanese workmen. The most valuable turtle for its size is probably



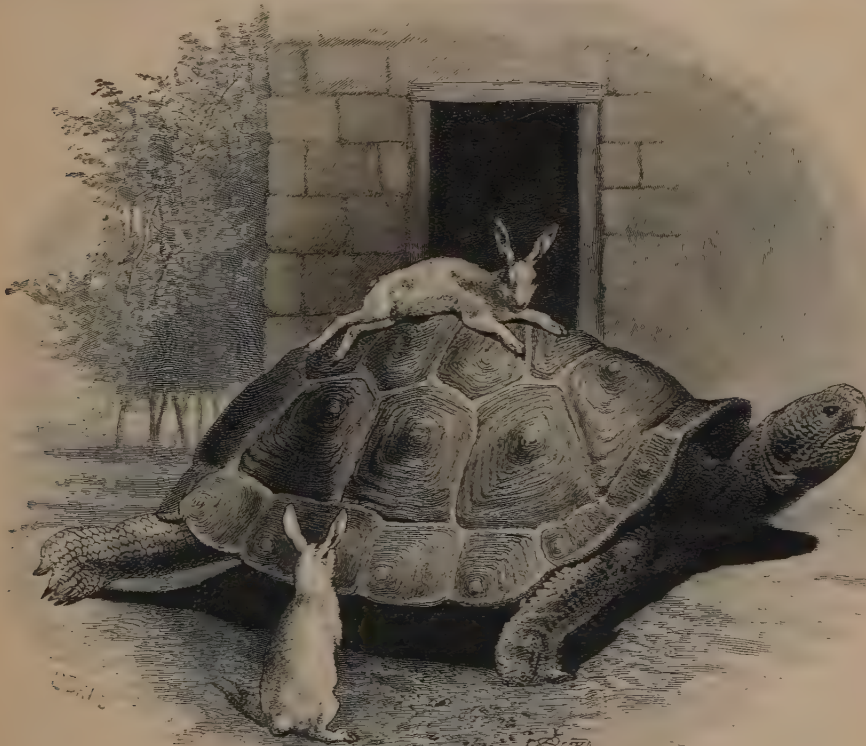
THE DIAMOND-BACK TERRAPIN.
Length, when full-grown, one foot.



THE GREEN TURTLE.
Length, when full-grown, five feet.

or as the hawkbill, another sea-turtle found in tropical waters, whose shell furnishes the tortoise-shell used for making the fine combs worn by our

the diamond-back terrapin of the marshes along our Eastern coast to the south of New York; for this is considered such a delicacy that it brings from one to three dollars apiece, and it is a good large terrapin whose shell is over eight inches long. The largest of living land-turtles, or tor-



A "HAPPY FAMILY" OF FRISKY YOUNG HARES WITH A GALAPAGOS TORTOISE, KEPT IN A PARK.
Length of tortoise, when full-grown, five feet.

toises, come—or came, for they are almost eaten out of existence—from the Galapagos Islands off the coast of Ecuador, and the shells of these are three, four, even five feet long, and their owners are as many hundred pounds in weight. One of these tortoises is so strong that it can readily walk off with a full-grown man on its back; and they were once so numerous that whaling-vessels were accustomed to visit the islands for the purpose of laying in a supply of them for food. It has been estimated that in this way no less than ten million tortoises were taken. Very similar tortoises are found on the island of Aldabra, and were once found on Mauritius and Bourbon; but on those two islands they were long ago all eaten up. Tortoises grow very slowly, but they seem to keep on growing as long as they live, so the size of a tortoise tells us something of its age. One taken to Sydney in 1853 weighed 53 pounds, while at the time of its death in 1896 it had increased to 368 pounds, so that the animal was probably from fifty to sixty years old.

But fossils from northern India show that in ages gone by tortoises grew even larger and stronger than this, and it has been imagined that



THE "ELEPHANT" TORTOISE.
Length, when full-grown, four feet.

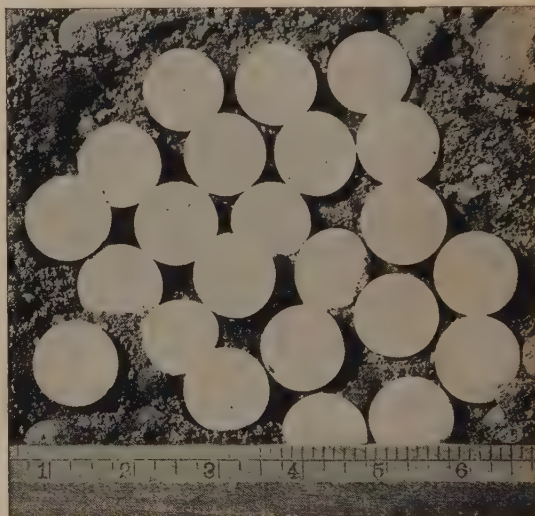
legends of these giant turtles may possibly have given rise to the Hindu belief that the world rested on the back of an elephant, which in turn stood on the back of a great turtle, but what the turtle stood on we don't know.

The king of all turtles, however, alive or dead,

Archelon is his name, swam in the seas that once rolled over the State of Kansas; and the head alone of this monster was larger than a big snapping-turtle—that is to say, it was three feet long and correspondingly broad—while as nearly as we can estimate the entire animal was twelve or fourteen feet long. Associated with this turtle were hosts of great marine reptiles and powerful fishes with teeth like spikes; and when these creatures were all hunting for a dinner there must have been troublous times for the little fishes in those old Kansas seas!

SNAPPING-TURTLE EGGS

A SNAPPING-TURTLE lays about two dozen eggs. These are placed in damp sand in a hollow scooped out by the turtle. The mother turtle



SNAPPING-TURTLE EGGS.

almost or wholly buries herself in the sand. Then in crawling out she lets the sand over her shell fall upon the eggs, thus covering them. The eggs are white and almost perfectly round, and have a very thin, hard shell.

"GRIP," THE TALKING CROW

BY EUDORA BLACK

"GRIP" was his name. He was so called in honor of the talking raven immortalized by Charles Dickens in his story "Barnaby Rudge." Whether he proved worthy of the name I leave to my readers to judge.

Ever since I read of the original Grip I longed to possess a raven. But there were no ravens in the country in which I lived, and the next best thing was his cousin the crow. I had heard and read of crows becoming interesting pets; in some

instances, of their learning to articulate a few words after having had their tongues split—a cruel operation which I did not believe gave them the power of speech. It seemed as unreasonable as it was cruel, and I want to say that my pet was never subjected to such torture. He learned to talk by using his tongue as nature fashioned it.

Grip came into my possession in this wise: One day in April I chanced to meet a couple of urchins who had been robbing and destroying crows' nests, thinking they were doing a vast good for the farmers by exterminating the robbers of their corn-fields. I had long believed that the crow was not so black as he was painted, and that for every kernel of corn he stole he destroyed many grubs and insects, which would have injured the crops far more than the bird could have done with all of his depredations.

A sorrier object I never saw than this poor kidnapped baby crow crouching in the folds of a ragged and tattered old hat. He was very ugly in his half-fledged feathers, with large head and long beak, but he looked so pitiful that my heart went out to him at once.

"What good are crows, anyway?" said the boy.

"Then give him to me," I suggested.

To which the urchin replied:

"You don't get a crow every day, miss."

I saw in the lad's eyes that he wished to bargain as he told me how he and Jimmy, his comrade, had climbed to the very top of a tall tree in quest of the nest wherein he had found the baby crow, and of how the old ones had circled around, fairly flying in their faces and trying to pick out their eyes, and, worst of all, how the limb broke and he nearly fell. I said:

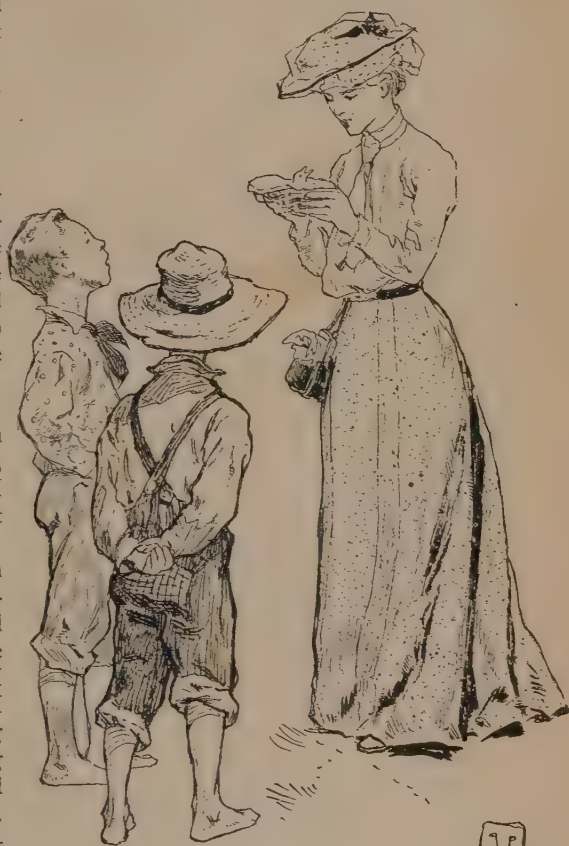
"Well, then, sell him to me."

We soon had made a bargain. The boys then ran off with happy faces and still happier hearts, clutching a few dimes in their little fists, while I proceeded homeward with my newly found pet wrapped in my handkerchief.

As soon as I had reached home I placed him in a good-sized chicken-crate under a large pine-tree in the front yard, where I fed him bread and milk, which he gulped down greedily, and, like *Oliver Twist*, kept on crying for more, until I thought his appetite never would be appeased. I kept him in the crate for several days, feeding him very often. When he saw me approaching he would spread his wings, open his mouth, and shrilly "Caw, caw, caw!" for something to eat. His appetite was voracious. He would eat anything given to him; meat, bread, cake, fruit, eggs, all went greedily into his gullet. I wondered how the parent crows ever kept filled the maws of a hungry family.

Grip, as I called him, soon grew quite tame; so I left the door of his house open, and he went in and out at his pleasure. He showed no disposition nor inclination to wander away, but spent the day hopping around the large yard, hunting worms and insects, pulling the long grass, and carrying about little sticks in his beak. He came to me readily to be fed from my hand. At night he would go into his house to bed, which was a perch, just as a chicken would go to roost.

Grip's babyhood did not last long. He grew so rapidly that in three weeks he was a full-fledged crow, with beautiful glossy black feathers, of which he was very proud. He bathed regularly every morning in a pan of water I kept under the tree for him, and how he would dress and preen his feathers! He was, in truth, a handsome bird, and well he knew it. He could fly, and the chicken-crate no longer served him for a bedroom. He found one more to his liking in the pine-tree. The chicken-crate, alas! be-

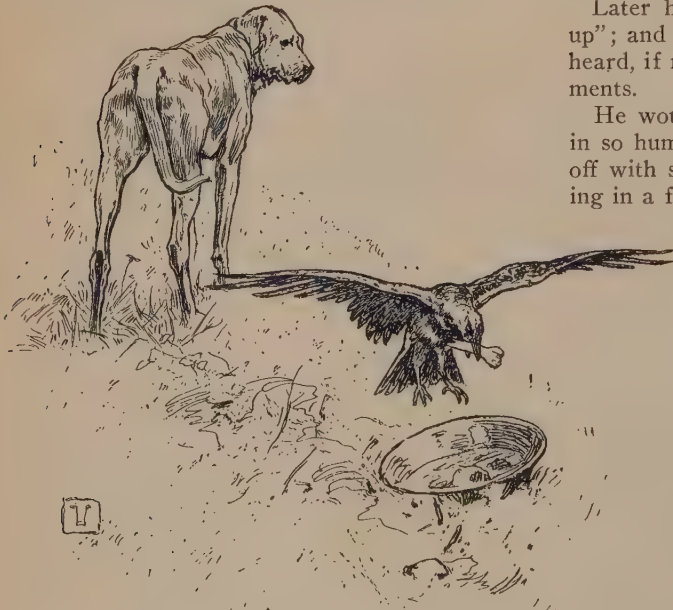


"WHAT GOOD ARE CROWS, ANYWAY?"

came his prison at times. He had begun to grow very mischievous. On the family wash-days he had to be shut up, else all of the clothes-pins would be plucked from the line. Small articles, also, such as collars, handkerchiefs, and the like, would be missing. We soon learned that Grip was a cunning thief. He would fly into the house, snatch up a spoon or any other bright object he could carry off, and take it to some secret hiding-place.

A large bed of pansies near the house, which was my pride, was his especial delight. Every morning I would pluck the blossoms, which were so like little faces that smiled up to me. Grip was always on hand to assist me; but he would ruin every flower by snipping it off, and he did it so spitefully, I knew that he was jealous of the flowers I loved.

"Go 'way, Grip, go 'way," I would say to him, sometimes using a little switch to drive him off. The moment I was out of sight, however, down he would swoop again into the pansy-bed, and "snip, snip" would go their heads. There was scarcely an hour in the day when some one was not calling out, "Go 'way, Grip, go 'way," for the whole family kept watch over those pansies.



"THE POOR OLD DOG ACTUALLY LEFT HIS BONE AND WALKED OFF WITH AN INJURED AIR."

At times Grip would be very loving. Alighting on my shoulder, he would cuddle down close to my face, uttering soft little croaking notes. Then he would slyly pull the pin from my collar, and

begin snatching at the hair-pins in my braids. At other times, when I called him, he would not come to me, but would alight near me, and look at me so impishly while I pleaded, "Come here, Grip; come, Grippy, come here."

One day I was coaxing him thus as he hopped along on the top board of the fence. He put his head down and seemed to be choking and swallowing. After several such spasms he uttered the words, "Go 'way, Grip, go 'way," very distinctly. I could hardly believe my ears. Grip my crow could say three words: "Go 'way, Grip." For a long time he had chattered and made guttural noises. He would scream and laugh like a young imp. But now he could talk, and, aside from being surprised, I was delighted. He soon learned to say, "Go 'way, Grip," without effort, and not long after that I heard him say, "Come here, Grip; come, Grippy, come here," in the same coaxing tone I used to him.

Rainy days were his delight. Then he held high carnival on the woodpile, where he would chatter and laugh, coax and scold by turns: "Come here, Grip, come here," in a soft, coaxing tone; then harshly, "Go 'way, Grip, go 'way." It sounded as if two children were quarreling.

Later he learned to say, "All right," "Hurry up"; and almost any hour in the day he could be heard, if not seen, practising his new accomplishments.

He would scold the dog, "Go 'way, go 'way," in so human a voice that "Towser" would sneak off with slinking tail. Once I heard Grip scolding in a furious manner. He was perched on the garden gate. Towser was gnawing a bone. Grip continued his angry "Go 'way, go 'way," until the poor old dog actually left his bone and walked off with an injured air. Mr. Grip then flew down and took possession of the bone, chattering, screaming, and laughing, "Ha, ha, ha!" over his victory.

The cat, "Tom," a fine Maltese and a household pet, received his share of Grip's teasing. When he was lapping his supper of new milk, or dozing peacefully, Grip would slip up behind him like a black imp, and give his tail a tweak. Puss would utter a distressed yowl, and spring up with swelling tail, and green eyes flashing with fury. It was well for the tormentor that his strong wings could take him out of reach.

The chickens, too, were often annoyed by this busy mischief-maker. I feared he might kill the

little chicks, but he never harmed them. He was not cruel, and was only teasing out of pure mischief.

This he accomplished with the fowl by swooping down upon them like a hawk, brushing them with his wings as he flew by, causing a great cackling and flurry among them, which excitement he greatly enjoyed. Again, he would startle them by loud cackling such as theirs.

How can I relate all of Grip's pranks? He was so busy each day! A favorite occupation and diversion of his was to go into the cellar where, on a swinging shelf, the old bottles were kept. He would spend hours pulling corks and rolling the bottles about, chattering and talking the while.

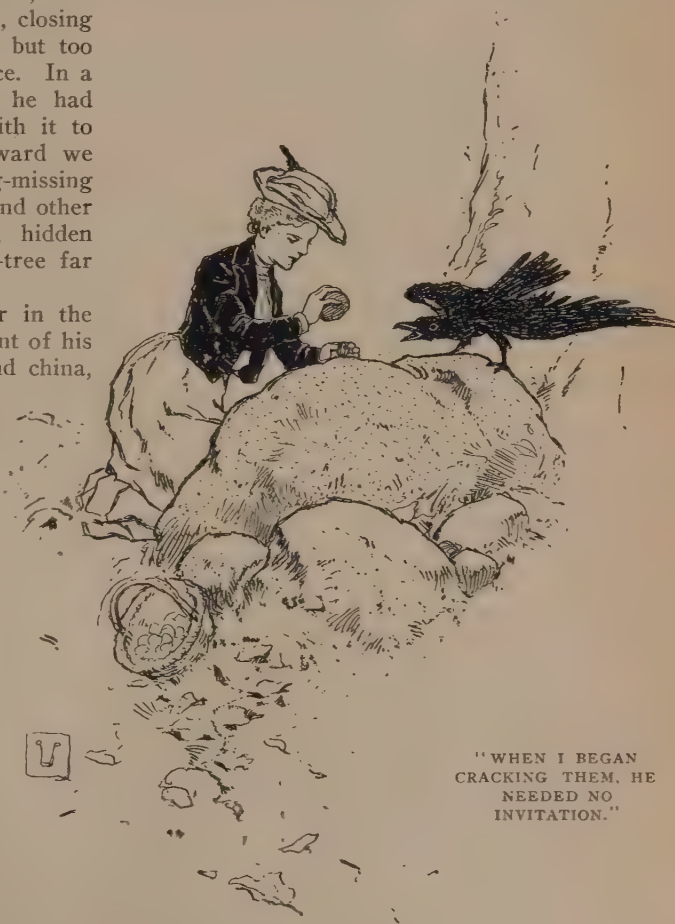
All bright trinkets attracted his attention. One day my little sister sat in the window, counting the pennies in her purse. Grip flew up on the window-sill and watched the operation. She jingled the pennies and shook them at him, then dropped them one by one into the purse, closing it with a snap-catch. I cautioned her, but too late. Grip had been watching his chance. In a twinkling, and quicker than lightning, he had snatched the purse and flown away with it to some secret hiding-place. Long afterward we found the purse, together with a long-missing thimble, a spoon, several button-hooks, and other small articles which he had pilfered, hidden snugly away in the hollow of an apple-tree far out in the orchard.

When the pansy-bed was raked over in the spring, there, too, we found an assortment of his treasures, consisting of bits of glass and china, nails, corks, and hair-pins. All these he had secreted there. It seemed that the things he valued most, or that he feared we would take from him, he had cunningly hidden in the tree.

The autumn days came, and many a pleasant excursion Grip and I had into the woods gathering hickory-nuts. It was but a short walk. With my basket on my arm, and with Grip in high glee perched on my shoulder, I would start out. The hickory-trees were scattered through the wood. After his first trip with me, Grip knew where they were as well as I did. When the nuts had all been gathered under one tree I started with my basket for the next nearest one. He would wing his way there ahead of me, and begin his work, that of shucking the nuts. He knew that each nutshell contained a goodly morsel, and tried to crack them in his beak. When I found a stone and began cracking them,

he needed no invitation, but came begging me with open mouth for his share of the toothsome kernels.

One afternoon when we were busy with the nuts, Grip suddenly flew to a high limb on the tree overhead, and began cawing in a loud and distressed manner. I knew that was his danger-signal, so I started for the orchard fence as rapidly as my feet could carry me, not daring to look behind, fearing there was an enemy in pursuit. Grip kept up his cawing. I knew that distressed cry meant *something*. Grip was a rogue and a thief, but he was also wise and knew when to sound an alarm. I had heard that warning cry before, and his fright was never groundless. Soon a low, rumbling sound, like thunder, fell upon my ear. Nearer and nearer it came. Venturing then to look behind me, I saw a cloud of dust, and in it many forms rushing by the open



"WHEN I BEGAN
CRACKING THEM, HE
NEEDED NO
INVITATION."

where I had been gathering nuts. It was the cattle. A large herd was stampeding to the woods



GRIP AND THE SCHOOL CHILDREN.

from the pastures below. They were in great fright; possibly stray dogs were chasing them. Had I not fled at Grip's cry of danger, I might have been trampled under the hoofs of the stampeding herd.

Then I knew why Grip always showed a wish to accompany me wherever I went. He had constituted himself my guardian and my protector. The moment I went out of the door he was on hand to go. However, he would not go far from home. When I drove, he rode along, sometimes on the back of "Coaly," the horse he had a fond-

ness for, perhaps because she was jet-black like himself (hence her name Coaly), and sometimes on the back or top of the buggy. If in the latter position, he would peer over the front at me, looking very cunning as he did so. After seeing me safely on my way, he soared off home, and went about his business, which seemed to be that of looking after everything on the farm.

He was particularly busy when the fall harvest of fruits and vegetables was being garnered, going back and forth continuously between field or orchard and cellar with the men. He also



"HAD I NOT FLED AT GRIP'S CRY OF DANGER, I MIGHT HAVE BEEN TRAMPLED
UNDER THE HOOF OF THE STAMPEDING HERD."

took great interest in the barn-chores, following the men about as they cared for the dumb and faithful creatures. Now and then would be heard Grip's voice saying, "All right," "Hurry up." Perhaps he would be circling high overhead. It caused one to have a strange and uncanny feeling. He would perch on the orchard fence when the horses were turned out to graze awhile every evening, and call: "Cope, Coaly, cope, Coaly, cope, cope, cope!" as he had heard the men call.

During that fall I taught the district school, half a mile from home. It was a pleasant walk, in good weather. Grip was on hand to see me safely on my way each morning. He would hop or fly along, or ride on my shoulder, until he came to the bridge which spanned the creek just half-way to the school-house. Then he would fly up into a tall willow-tree bending over the water. Thus far would he go, but no farther.

One morning, however, he alighted on the win-

dow of the schoolhouse, tapping loudly with his beak upon the glass to be let in. The children all knew Grip. He was famed throughout the neighborhood for his powers of speech and his impish and cunning pranks. Immediately the hands went up to beg permission to let him in, with promises to be good and to study hard.

The unanimous request was granted, and Grip flew to my desk and began picking up pencils and pieces of chalk. Then he went from one desk to another, looking for more pencils. No doubt he thought he had struck a rich field. I must confess that lessons were forgotten, so intent were the children in watching this strange bird, which hopped from desk to desk and peered into their faces in such a curious way.

When it was time for recess Grip had a merry play with the children, who knew how to entertain him. They fed him choice tidbits from their dinner-pails, drove little sticks into the ground for him to pull out, and gave him their handkerchiefs to pull by the corners. These he would tug at and pull until he "was black in the face," as one little girl remarked, and then he would hang tightly on, beak and claws, and be swung in the air.

When the bell rang, in he came again with the children, and perched upon my desk as much as to say: "Well, what next?" When we sang he cawed loudly with delight. At the end of the song, when all was quiet and lessons resumed, he began talking, saying, "Go 'way, Grip, go 'way," to express his disapproval of the silence, I presume.

It was useless to try to teach school with Grip there, so, like Mary's little lamb, he was turned out. He did not, however, like the lamb, linger patiently about, but winged his way home. On my return that night, there he was, my faithful sentinel, waiting as usual for me on the top bough of the willow-tree.

After that he was a frequent visitor at the school-house. He came in time for the forenoon recess, and when school was called again, not being allowed to enter the building, he soared off home.

The children learned from him lessons not to be found in books—of how there is much to learn from even the lowest of God's creatures. In the spring there was no robbing of birds' nests in that school yard; not a stone was thrown to frighten birds away. Grip's friendship inspired them with a love for all bird-kind and a desire to study their ways and habits.

By and by the winter days were upon us. Grip seemed to enjoy the cold and the snow. Instead of water-baths he now took snow-baths. He

would skim along over the snow, just brushing it with his wings, then take a plunge, wallowing in it as though he were in his accustomed water-bath under the pine-tree. Much of his time on stormy days was spent in the barn with the men. Often he would be seen sitting on Coaly's back, warming his feet. He liked to come into the house whenever the nuts which he had helped me gather were being cracked. The sound of the hammer always seemed to reach his ears, and brought him tapping at the window for admittance. When he had been fed with nuts until he was satisfied, he began to hide them about in the funniest places, slyly tucking one away under a cushion, another between the papers on the table or under the rug on the floor. The next time he came into the house he would begin hunting for his hidden morsels, and caw in great glee if he found them.

When the time came for him to go to roost he would watch his chance to fly out at the door and hie away to his pine-tree. One stormy night I nailed a perch high up in one corner of the woodshed. I then called Grip to my shoulder, from which he readily flew to the perch. After that he came every night at dusk to be put to bed in the same way. He slept there through the cold winter nights, well sheltered from the storms.

March came, and Grip was often seen circling around overhead with a flock of crows that frequented the place. I wondered if he would not select a mate and set up housekeeping in his pine-tree, and rear a family of talking crows. He was becoming more fluent in our language, every now and then adding a new word to his vocabulary, until it consisted of the following: "Go 'way, Grip, go 'way," "Come here, Grip; come, Grippy, come," "All right," "Hurry up," "Cope, Coaly, cope, Coaly, cope, cope," "Hurrah," and other words that were not quite plain enough to understand, but which, no doubt, he would have mastered in time.

But, alas! he came to an untimely death. One night he failed to meet me at the willow upon my return from school. No one had seen him that afternoon.

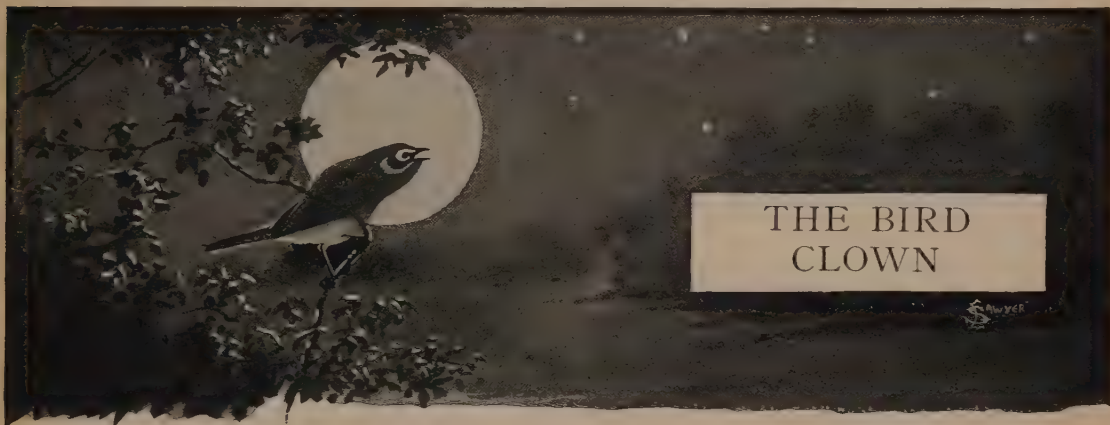
I found him in a shed, crouched upon an old barrel, looking very sick and miserable, and with green stains upon his bill. The can of Paris green was found overturned in the barn, and that told the story. The poor fellow had been eating the poison. He refused food, uttering plaintive little croaks as I stroked him and said, "Poor Grippy!" I left him for the night, hoping his crow constitution was strong enough to resist the deadly poison.

In the morning I found him sitting as I had

left him, but no soft croak greeted me. He was cold and stiff in death. Do you wonder that my tears fell freely, and that I felt no shame in weeping for a dead crow? Free as the air he had been—my willing captive, preferring to live among human beings rather than among his own kind. He even tried to learn our language. He was a thief and a marauder by birth, yet he had proved his possession of affection, intelligence,

and cunning far beyond my understanding of his wild nature.

I smoothed his glossy feathers, and gently and tenderly placed him in a little box, and buried him under his pine-tree, the boughs of which day and night for many years since then have sung his requiem. A little wooden slab now marks the spot, bearing the inscription: "To the memory of Grip, the Talking Crow."



"MORE THAN ONCE ON A MOONLIGHT NIGHT, I HAVE BEEN AROUSED BY HIS SPUTTERING."

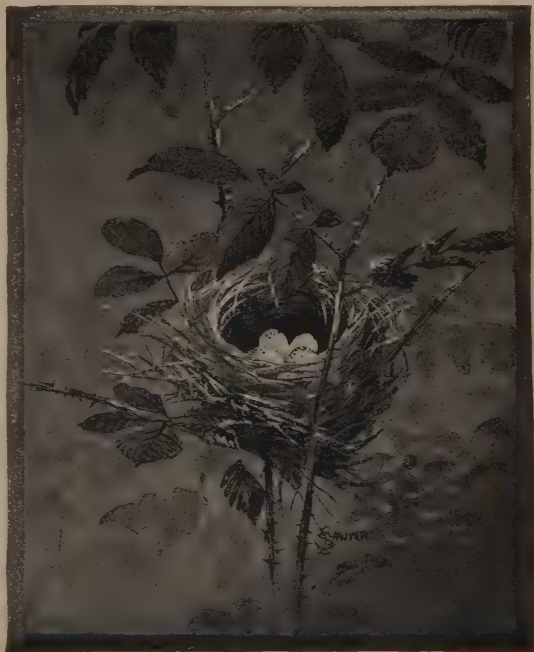
BUSHY undergrowths or thickets in partial clearings form the home of the chat. After an acquaintance of many years, I frankly confess that his true character is a mystery to me. While listening to his strange medley and watching his peculiar actions, we are certainly justified in calling him eccentric, but that there is method in his madness no one who studies him closely can doubt.

Is the odd jumble of whistles, *chucks*, and caws uttered by one bird in that copse yonder, or by half a dozen different birds in as many places? Approach cautiously, and perhaps you may see him in the air—a bunch of feathers twitched downward by the queer, jerky notes which animate it. One might suppose so peculiar a performance would occupy his entire attention, but nevertheless he has seen you; in an instant his manner changes, and the happy-go-lucky clown, who a moment before was turning aerial somersaults, has become a shy, suspicious haunter of the depths of the thicket, whence will come his querulous *chüt, chüt*, as long as your presence annoys him.—FRANK M. CHAPMAN.

the person that hears the song for the first time. More likely than not he will become invisible and

THE oddities of the yellow-breasted chat begin even with his classification. To think of a warbler the size of a Baltimore oriole! A warbler with a song like a mocking-bird! Indeed, there is little about the chat that is not remarkable; he goes in for the weird and the spectacular. If nature designed him to show what she could do in the way of the unusual and the eccentric she had remarkable success.

This bird, and not the catbird, is the real "clown of the woods." Clown of the thicket would be more apt, for, like the catbird, he prefers the shrub and lower trees; a wild tangle of briars and vines is a favorite haunt. It is only the better to survey such a retreat that he mounts to the top of a tree. From his lofty perch he sings, to the amazement and bewilderment of



A NEST OF THE YELLOW-BREASTED CHAT.

silent upon the first attempt to approach him, remaining quiet and hidden till you move on again; then he chuckles loudly and scolds and spits and scoffs till you are out of sight and hearing.

No bird is so fearful of being seen or such a master of hide-and-seek. It is worse than useless to try to steal a march on him. He manages to be always on the wrong side of the next bush; the one way is to find his nest, which is a pretty little basket of straws and weed-stalks, lined with fine grasses and strips of soft bark or leaves, placed a foot or more above the ground among tall weeds or bushes. The sitting bird steals away and is at once lost to sight. Take a peep at the white, red-speckled eggs and then hide



HE DELIGHTS TO DANGLE HIS LEGS AS IF
THEY WERE BROKEN.

Now he barks like a puppy, then quacks like a duck, then rattles like a kingfisher, then squalls like a fox, then caws like a crow, then mews like a cat. Now he calls as if to be heard a long way off, then changes his key, as if addressing the spectator.—JOHN BURROUGHS.

among the bushes as far away from the nest as you can while still keeping it in sight. You may have to wait for an hour and even make other trips to the spot, but this is the surest way to get a good look at this shy one.

Outlandish is the only word for the actions of a chat hovering high over his bushy haunt with dangling legs and ungainly flapping wings—a pet diversion. He is performing for his brown mate on her nest near by; he now fairly outdoes even



AN ASTONISHINGLY SUDDEN DROP.

himself. From the time he mounts laboriously until he drops helplessly back among the bushes his appearance is that of a clownish creature experimenting for the first time with wings and tail, and making a signal failure of it.

Not content with squawking, squealing, mew-ing and barking all day, he likes nothing better than to wake the peaceful birds by his midnight solos. More than once on a moonlight night I have been aroused by his sputtering. "Put-put-put, tut-tut-tut, cut-cut-cut-cut," he calls distinctly. A song sparrow or a chippy trills softly, thinking it is matin-time, but at once a volley of "cuts" and a loud burst of genuine hilarity greet him. It is the yellow-breasted chat enjoying one of his practical jokes.

EDMUND J. SAWYER.

WONDERS OF THE HUMAN BODY

TALKS WITH BOYS AND GIRLS ABOUT THEMSELVES

BY MRS. M. BERNARD

I. WHAT YOUR BODIES ARE MADE OF

ALL of you, healthy boys and girls, every day of your lives, are constantly using some part of your bodies—running, jumping, eating; seeing all the beautiful things in the world around you, hearing the birds sing and your playfellows talk; shouting with joy sometimes, and sometimes crying with pain. I wonder if you ever stop to think of what these bodies of yours are made, and how it is that they can do so many wonderful things with so little trouble on your part? Perhaps you fancy that it is only grown-up people that can understand about such things—that you need not trouble your heads about them. But I think you are quite able to understand some of the wonders that are going on every day and every hour inside of you, and I am sure you will find, if you listen to what I have to tell you, that the little palace you live in, your body, is quite as interesting as any fairy palace that you have read of in your story-books.

You all know what your bodies are like outside. If you were asked what are the different divisions of your body which you can see at once, I think you would say your head, your two arms and your two legs, and the thick middle part on to which all these are joined. Your arms and legs are often called your limbs, and the middle part your trunk; so we may say that your body is made up of a head, trunk, and four limbs.

Now there is one great difference between your head and trunk and your limbs. Your head and trunk are both like boxes filled with curious kinds of machines, which must work properly if you are to remain alive and well. But your arms and legs are not boxes; there is not any space inside

them. They are added on to the trunk, and used for defending it and the head, and for moving them from place to place.

Feel your arm and try to think what is inside it, before you read any further; then when you read on, you can see if you are right. You can all tell me what its outside covering is—what it is that you touch when you pass your hand over your arm. You know that it is your *skin* which is the smooth outside covering. It *feels* smooth to you, I am sure; but if you have a magnifying glass in the house, just hold it near your finger and look through it, and you will see that your skin is not really very smooth. On your hands and fingers it looks raised up into many ridges, and is folded and wrinkled wherever it has to bend. On your arm the skin is smoother, yet finely wrinkled, and pitted with numbers of tiny holes. In some places it seems to be peeling off, and hairs, which you can hardly see without the glass, stand up all over it.

What you see as the covering of your arms and of the rest of your body is only the outer skin; underneath it is another, much darker in color—quite red, in fact, like blood. There is one great difference between your outer skin and this lower one. If you prick the top skin with a needle, taking care not to pierce below it into the lower, you will feel no pain. The little girls among you have probably often run their needle through this upper skin while sewing, and you boys have no doubt sometimes had blisters on your hands from doing some hard work, digging in the garden, or rowing in a boat, or on your feet from the rubbing of a badly fitting shoe. Have you tried to prick them to let out the water that is in them? These blisters are made by the up-

per skin rising up from the lower, and the space left between them gets filled with what looks like water. It does not hurt you to put a needle through the upper skin; but if you prick deeper, and go through the lower skin, you feel pain, and blood comes out of the hole that is made. This shows you that there must be something in the lower skin which is not in the upper: something that feels pain, and some blood. If you could only see well enough through that little hole, you would find running through the lower skin a kind of network of very fine white threads, and another network of tiny pipes with blood inside them. The tip of the needle touched one of these little white threads, which are called nerves, and so you felt pain; it broke some of the little pipes which hold blood, and so a drop of blood came out of it.

When you get a bad cut, the knife passes through both the skins, and then what does it enter? Something firm and red which lies beneath the lower skin. This is your *flesh* or *muscle*, and through it in every part runs a network of fine white nerve-threads, and another network of tiny blood-pipes, very like those in the lower skin. So you feel pain, and blood rushes out; more pain and more blood than before, because, by going deeper, you have touched more nerves and pricked more blood-vessels.

The flesh, or *muscle*, as we must call it, lies in great pads and often in what seem like bands and ropes, everywhere under your skin, between it and the hard bones. Sometimes there is a great thick pad made up of many muscle-bands (as in the upper part of your leg), and sometimes only so thin a pad that you can quite well feel the hard bone beneath (as in your chin).

So now we have gone through two skins, a pad of fat, which in some of you is much thicker than in others, and a pad of red muscle, and at last we come to the hard bone which lies beneath them all and forms the stiff middle part of your arm or leg.

Just think for a moment of what use your bones are to you. What would your body be like without them? It would be nothing more than a soft bag, which could have no special shape and could not stand upright. If you were to make a straw man—as a scarecrow, perhaps—you would have to run a stick right through him to make him stand. As a straw man does not need to sit down or bend, one straight stick through him is enough; but you have not only to stand, but to sit and to walk, and so you have a kind of prop down your back, your backbone, and other bones down your legs and arms, which can move separately. When you think how very

many parts of your body you want to move, you will see why you need to have a great many different bones. Have you ever tried to count, through your skin, how many bones you have? You could not count them all, however much you tried, because they are joined together in many places where you cannot feel the joint as you can feel it at your elbow or knee. But if you try to count all the different hard pieces that you can feel in different parts of your body, you will find, I am sure, far more than you expect. My little girl of seven has been able to count more than one hundred! If you will try to count your bones in this way, you will be able to reach a certain number; then you will try to find out how many you really have, and how many you ought to be able to feel.

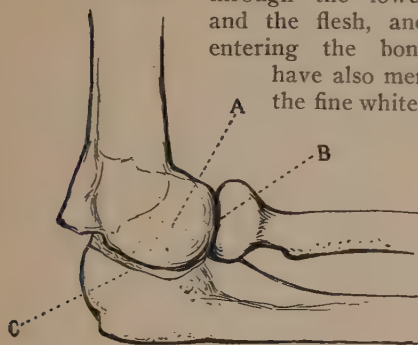
Your bones would not be of much use to you if they all lay loose in the flesh, and so they are very well joined together. Do you know how? Have you ever looked at the bones of a chicken's leg after you have taken off all the meat? Next time you have a chicken at dinner, ask to be allowed to keep the two bones of its leg, the drumstick and the thigh bone, and when they are quite dry you can scrape off any little bits of meat or gristle still on them, and see the shape of their ends, which made a joint before you separated them. When they are quite clean, see how neatly they fit into each other at the joint. One bone has a rounded end, and the other a scooped-out end, and the round part fits into the hollow. The one moves easily upon the other because there is always a little oily fluid at the joint. In the living chicken, tough, tapelike bands, called *ligaments*, tie the ends of the bones together, in such a way as to allow them to move, but not to come apart.

Your own bones all fit into each other at the joints something in the same way. Look at the two figures I have drawn of the elbow-joint. Fig. 1 shows you what your elbow would look like if the skin and flesh were all scraped off, and nothing but the bare bones left. At the part marked *A* you see the rounded end of the upper bone of your arm, and at *B* and *C* the scooped-out ends of the two bones which stiffen the lower part of your arm, and you see how easily the round end can move in the hollow made by the two scooped-out ends, especially as there is a little oily fluid between the bones. But in Fig. 1 there is nothing to hold the bones together. Now look at Fig. 2 and you will see, twisted round the elbow-joint in various directions and partly covering it, the bands or ligaments which fasten the upper and lower bones together. Now if you imagine the bones and ligaments you see

in Fig. 2 covered with red muscle, then with a layer of whitish fat, and then with your two skins, you will have an elbow made just like your own.

We have now talked of your skin, fat, muscle, and bones, and the fine blood-vessels running all through the lower skin and the flesh, and even entering the bone; we have also mentioned the fine white nerve-

Fig 1.



threads, which help you to feel, and also, as we shall see later, to move. All these—skin, fat, muscle, blood-vessels, and nerves—are to be found not only in your arms and legs, but all through your body.

We have already described your trunk and head as boxes. But what is inside these boxes? Something that is not to be found in your arms and legs—a whole set of wonderful machines which you are constantly using, and some of which go on working even when you are fast asleep!

Your trunk is divided into two parts—into an upper and a lower box, as it were. In the lower box of your trunk, which is made of skin and muscle, so that it can change its shape, you have a very large machine with many different parts for receiving the food you eat, and changing it. The name of this machine I think I need not tell you, for all little boys and girls have at some time or other had pain after eating something that was not good for them, and were told that it was *stomach-ache*. Then, in the upper box, which is like a basket with your bony ribs for its sides, you have a machine for breathing, called your *lungs*, and another for pumping the blood through your body, called your *heart*. Lastly, in the very solid, bony box, the sides of which you feel as you pass your hand round the upper part of your head, is the most wonderful and precious machine of all, which helps all the other machines in your body to do their work. This is your *brain*.

There are many other curious machines and

arrangements in your bodies, and when you are older, I hope you will learn about them; but these are all we need mention now, so that you may follow what I want to tell in another talk.

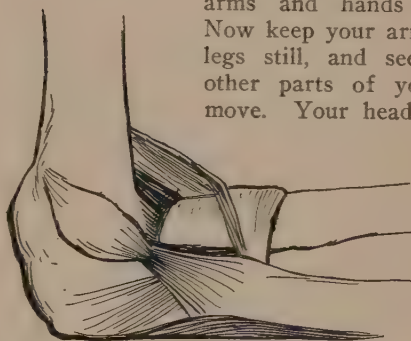
II. HOW YOU MOVE

ALL healthy boys and girls move about and use their bodies a great deal. If we see a child sitting and doing nothing, with feet and hands still, and not speaking a word, we think there must be something wrong—that he is ill. I dare say you are often told that you move about too much, your tongues as well as your feet making too much noise sometimes, so that grown-up people say: "Oh, children, do be quiet!" or "Do try to make less noise!"

Just think for a moment what parts of your bodies can move. When you walk or run, your

legs and feet move, and when you throw or take hold of something, your arms and hands move. Now keep your arms and legs still, and see what other parts of you can move. Your head, I am

Fig2.



sure you will say at once, as you nod or shake it. Then keep your head still, and see what else is moving. Your eyes can still look half around the room, and you can move your eyelids up and down. Your lips can move to smile, and your tongue to talk and laugh; your jaw, the big bone that makes your chin, can move to eat. Can you move any other part of your face? Your nose? Yes, just a little; and your ears? Perhaps some of you can, but probably most of you cannot.

Even if you try to keep as still as possible, you can't help some parts of your body moving. Just try. You will soon find that your eyelids close quickly over your eyes, and that you cannot keep them from doing so for very long. And even if every part outside your body is still, some part inside is always moving. Your chest is rising and falling as you breathe; your heart is beating; your blood is rushing through the little pipes all over your body; and many other parts

inside you are moving whose movements you cannot feel.

Now what is it that makes all these different parts move? Perhaps you will say: "*I* make them move when I like"; but although you may be said to make your leg or arm move when you walk or catch hold of something, you do not make your heart move; and even if, as you say, you do make your leg and arm move, I want you to know *how* you make them move.

When we spoke, in our last talk, of the different things of which your bodies are made, we mentioned the red muscle that lies everywhere under the skin, forming pads sometimes, and sometimes a kind of ropes. These ropes of muscle are very important, for it is they that move your arms and legs, and other parts of your body.

When you wished or *willed* it, this muscle suddenly grew short and thick, that is, it contracted, and so pulled the lower part of your arm up.

Look at the two figures I have drawn of an arm. In Fig. 1, the lower part of the arm lies out flat, as it would if resting on a table, the elbow being half bent. *SH* is the shoulder-joint, and *EL* the elbow-joint, and *M* is the muscle which passes from the upper to the lower part of the arm. *T, T, T*, are the tendons by which the muscle is made fast. In Fig. 2, all is the same, except that the muscle has changed its shape and is much rounder and shorter than it was in Fig. 1. By growing thicker and shorter, it has pulled the lower part of the arm up. Now you can understand that muscles, by contracting, bend your arm (or leg) if they are on one side

Fig. 1.

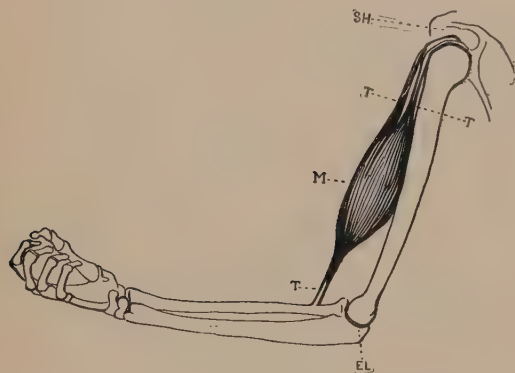
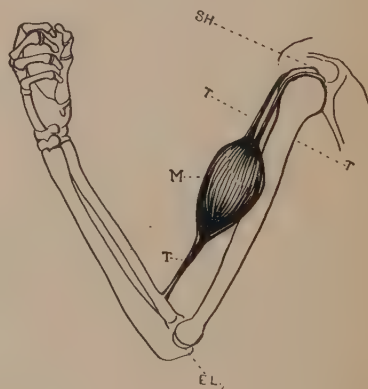


Fig. 2.



These fleshy ropes are fastened at both ends; near each end the rope gets rather thinner, and turns into a sort of strong cord which is called a *tendon*, and these tendons are fastened to bones; they are not tied on, but they and the bones grow together. But though we have called muscles fleshy ropes, they are quite unlike ordinary ropes in one way, for they have a curious power of suddenly growing shorter and thicker. When a muscle draws itself together in this way, it is said to *contract*.

You can feel a muscle shorten and thicken if you like. Stretch your right arm out straight, then lay your left hand on it just inside and a little above the elbow, and hold firmly. Now suddenly bend up your right arm, and what do you feel? Something hard rises up under your left hand. That is the muscle which is fastened at one end to the upper part of your arm bone, and at the other to one of the two bones of the lower part of your arm, just below your elbow.

of the joint, and straighten it if they are on the other.

You have hundreds of muscles in different parts of your bodies, all contracting when necessary. All your bones are moved by means of muscles, and all the different machines of which we spoke last time—your stomach, heart, lungs—are worked with their help. Some of these muscles, as we have already said, go on working just the same whether you are awake or asleep.

You not only need to use your muscles to walk or run, but you have to use them even to stand and sit straight. Have you ever watched any one go to sleep sitting in a chair, and seen what happened? His head first nodded when he began to feel sleepy, and then when he really slept, it fell forward on his chest. Why? Because, to keep the head upright, some of the neck muscles have to be contracted, and when you fall asleep you lose the power of making some of your muscles do their work. This is why it is

so tiring to stand for a long time, and why lying down is such a rest, because when lying, especially on a soft bed, all your muscles can rest, except those which never rest, like those of the heart. During sleep, however, even your heart gets a kind of rest because it beats much more slowly.

We all have to learn to use our muscles rightly. Perhaps you have a tiny brother or sister that you saw when it was only a day or two old. Do you remember how its little head always had to have something under it, because the baby could not hold it up? It learned to hold it up after a few weeks, but it took much longer to learn to use some of its other muscles—to stand, to walk, and to run. You all had once to learn how to do these things which now seem so easy.

If we use our muscles very much, they become strong and thick. Have you seen a strong man rowing? If you can see his bare arm, you can watch how the muscles rise up like thick ropes as he works with them.

When we speak of some one being strong, we mean that his muscles have grown powerful by being a great deal used. All of you children need to walk and run about so as to strengthen your muscles. If you were to lie down most of the day, and hardly use your legs and arms at all, your muscles would grow thin and soft, and soon

you would not be able to use them any better than your baby brother or sister could at first.

You know now that you are helped to make all your movements by the contracting of your muscles; but what is it that makes your muscles contract?

Do you remember the fine white threads we mentioned in our last talk—the nerves, which run through every part of your flesh? These all come from that wonderful machine in your head, your brain, or from a long nerve-string which passes from it down your backbone, and it is these which bring a message to the muscles when it is necessary for them to contract. They are like wonderful, living telegraph-wires carrying messages. Sometimes it seems to you as if you yourself sent the message because you know what is going on in your brain; but at other times the brain may work and the nerves may be carrying their messages without your knowing anything about it. If your brain were hurt, so that it could not work, not one of your muscles would be able to contract.

So you are able to walk and run because your muscles can contract; and they, in contracting, are only obeying messages sent to them through the nerves which run to them from that wonderful brain that rules your body.

A FEW CURIOUS QUESTIONS

WHAT ARE FRECKLES?

WHAT we usually speak of as freckles are spots of a yellowish-brown color which are seen on the skin of some people, especially after they have been exposed to strong sunshine for some time. They occur chiefly on the face, on the neck, and on the hands, because those are the parts of the skin unprotected by clothes. Some people are much more liable than others to have this coloring produced, and in some it disappears quite quickly, while in others it lasts a long time.

In all these cases the freckles are the result of the action of the sun on certain cells of the skin, which causes these cells to produce coloring matter, or pigment, which remains there for a certain time. There are cases, however, in which freckles do not appear to be caused by very hot sunshine or exposure, but which come naturally, just as the color of the skin itself is either fair or dark, according to the tendency inherited by the individual.

WHY IS YAWNING INFECTIOUS?

THE first and most urgent necessity in the lives of all of us is to breathe. A yawn is a very deep breath. It depends, as a rule, upon the fact that from one cause or another—it may be that we are bored, or it may be that we have some illness—our breathing has fallen below what is needed, and the yawn is an attempt to make it up.

Now, it is a very well known fact that one human being can affect another by what is called suggestion. A boy sees another boy eating a chocolate, and of course he wants a chocolate; one person sees another person afraid, and then he becomes afraid; if everyone around us is laughing and happy, we begin to laugh and feel happy; or if they are all in the dumps, we get in the dumps too. And yawning is more powerfully conveyed by suggestion—infectious, as we say—than almost anything else we know of, because it happens to deal with the most urgent and constant need of all life, which is to breathe.

TALKS ABOUT OURSELVES

WHAT THE BODY IS

THE body consists of bones, flesh, and blood, and is composed of different parts or organs. Its covering is called skin.

Each part of the body has a different name. The upper extremity, which is covered with the substance known as hair, is the head. The middle part is the trunk. The lower extremities are the legs. The legs consist of the thighs, knees, shins, ankles, feet, and toes. The arms consist of upper arms, elbows, forearms, wrists, hands, fingers. Arms and legs are often called limbs.

The chest is separated from the abdomen by a partition made of muscle called the diaphragm. The food-pipe and some blood-vessels and nerves pass down through openings in this muscle into the stomach.

Carefully lodged in the upper part of the trunk, in the chest or thorax, beneath the ribs, is the heart. There also are the organs of breathing—the lungs.

In the lower part of the trunk, in the belly or abdomen, are the stomach and various organs of digestion and many other parts, such as the liver, kidneys, and intestines, that assist the principal ones to carry out their work.

The front part of the head is called the face, and contains the organs of sight, hearing, taste, and smell. The face is outside the skull. Above and at the back of the face, safe inside the skull, is that wonderful organ the brain, wherein lies the power that controls our bodies, and which causes us to feel, and enables us to move.

The bony framework of the body, upon which the flesh is bound and which keeps the flesh together, is the skeleton.

The work of the body is carried on by different sets of organs, or systems as they are often called. They are: The bony system, or framework of the body; the digestive system; the circulatory system; the respiratory system; the muscular system; the nervous system, including the five senses; the organs of excretion.

THE FRAMEWORK OF THE BODY

THE study of the structure of the body is called anatomy, the science that tells us about the different parts of the body, where they are placed, and what they look like.

The bony framework of the body is called the skeleton. It is composed of about two hundred

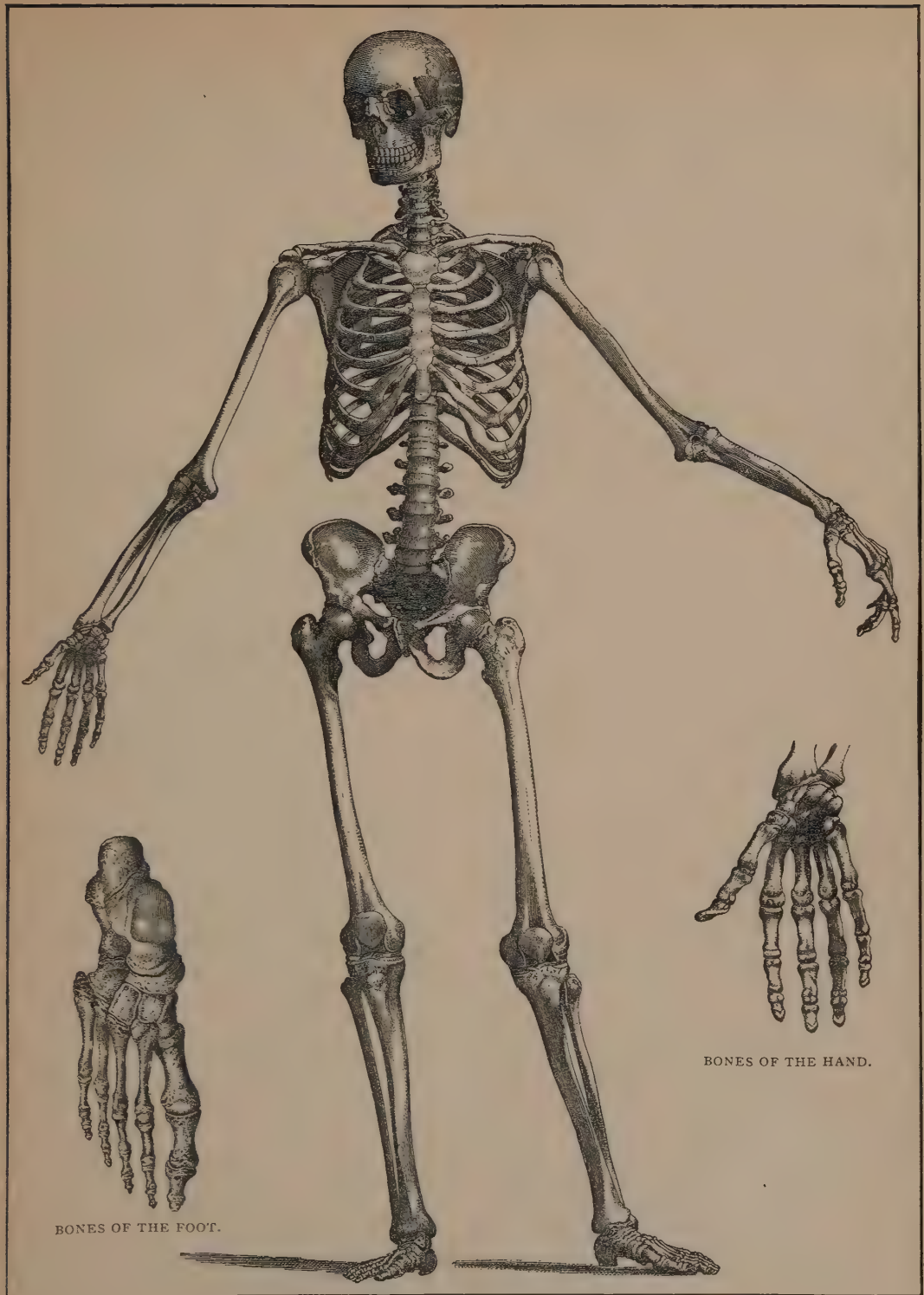
bones. The flesh (or muscle) of the body is fixed to the bones, and is covered by the skin. The skeleton gives the body its shape, and protects some of the softer organs which lie in the cavities of the body—the skull, the chest, the abdomen, and the pelvis.

Bones, as we all know, are made of a very hard white material. Some of us have picked up the bone of a dead animal from the roadside. Except for the dirt on it, the bone was white; but when it was part of a living animal that bone was a very pale pink color; this color was caused by the blood which was in the cells of the bone, because bone like every kind of animal tissue has to be nourished by blood. Bones consist chiefly of a chemical substance called phosphate of lime, which is a compound of two elements, phosphorus and calcium. They also contain an animal substance called gelatin, which can be removed from them by boiling. Some animals eat bones in order to obtain this substance for the nourishment of their bodies. No careful housekeeper throws meat-bones away. They should be boiled down into good, nourishing "stock" from which soup is made.

In fresh bones there is a substance called marrow; this is stored in hollow spaces or tunnels in the middle of the bones. Marrow, which helps to make new blood, looks something like soft fat. Bones have thousands of other little tunnels all through them. In a live animal these passages contain the blood-vessels, which bring nourishment to the bones. For although bones are so hard, the substances of which they are made are brought to them by the liquid blood from the food. Babies' bones are not hard like those of grown-up people. They are made of a softer yellowish substance, called gristle, or cartilage. All children have gristle in some of their bones. These harden gradually as they grow up.

Bones are of different shapes and sizes according to the uses for which they are intended. Thus, the breast-bone is flat, the bones in the arms and legs are long, those in the fingers and toes are short, those in the spine are compact and very strong. The fact that bones are mostly hollow makes the body lighter than it would be if they were solid, for bone weighs very heavy.

Wherever the different bones are fixed together or have the power of turning, they are joined or connected by joints; to keep these in place the joints are bound together by ligaments. The bones do not move themselves. They are pulled about at the joints by the muscles which are at-



THE HUMAN SKELETON.

tached to them. Some joints, such as the shoulder, which is a ball-and-socket joint, and the knee and finger joints, which are hinge-joints, are made so that the bones that form them move and bend on each other very freely. Others, like the joints between the bones at the lower part of the spine, and those of the pelvis, allow less movement. The bones of the skull are fixed tightly together and cannot move at all.

The ligaments which bind the bones together at the joints are of two kinds. Some look like round thin ropes, and others like strips of stout linen. Both kinds are made of a fibrous tissue, which is very tough.

Occasionally an accident happens to some one which forces the end of one of the bones in a joint through a ligament. The bone is then said to be out of joint, or dislocated; it has to be forced back again by a doctor, and the sufferer has to rest it until the hole in the ligament has healed.

Supposing the bones in the joints were quite bare and dry, they would scrape and grate against each other every time they were moved by the muscles. To prevent this the end of every bone is covered with a cap of gristle which makes a kind of cushion for it. This allows the bones to move against each other smoothly, and also prevents them from jarring against each other when we run or jump. In the inside of the joint is formed an oily fluid which enables the bones to turn easily, just as oil in a lock enables a key to turn smoothly.

THE BONES OF THE SKELETON

THE human body, the most delicate and wonderful formation of which we have any knowledge, has for its foundation a skeleton containing about two hundred variously shaped bones, big and little. In studying more particularly about it let us begin with the head, or skull, and end with the toes.

The skull gives the head its shape. Inside the cavity of the skull is the brain, and outside, on the front, the face is fixed. At the side of the skull are the two ears. The face and its features give us what is called our expression; and it is by the face that we generally recognize one person from another.

The skull is joined to the rest of the skeleton by a column of bones placed one upon another. This is called the spine, or backbone, and the bones of which it is made are called *vertebræ*. The joint between the skull and top of the spine allows us to nod or turn our heads by means of the action of the muscles of the neck.

The upper and back part of the skull is called the *cranium*. It consists of eight bones, some flat in shape, and some curved, and joined so closely to one another that they cannot be moved. The skull thus forms a hard round case to hold the brain, which is placed inside its upper part.

The bones at the front and lower part of the skull form the face, which is composed of fourteen bones. Except the lower jaw, all of these are united so that they cannot be moved. The lower jaw is joined to the skull by means of a joint, which enables it to move. The face-bones surround the mouth, and above this they form a sort of tunnel which opens into the nose. There are two deep holes in the upper part of the face-bones; these are the sockets for the eyes. The nose is only made of bone at its top part; the lower part is made of gristle. The ears are not formed of bone, but of gristle covered with skin.

The teeth are planted in ridges in the jaw-bones, which are covered by fleshy cushions called the gums. We have two sets of teeth during our life. The first, the milk-teeth, appear when we are still babies, in the first two years of our life. They are twenty in number. When children grow older they lose their milk-teeth; these are pushed out by the permanent, or second, set of teeth growing up beneath them. We ought each to have thirty-two permanent teeth, sixteen in each jaw, though we do not get the last of them, our wisdom-teeth, till we are grown up.

The spine is formed of a number of bones that, as already said, are called *vertebræ*. It keeps in place all the bones belonging to the trunk, and it is joined to the lower part of the skull. The *vertebræ* get smaller where they join the skull. All the bones of the *vertebræ* have thick cushions of gristle between them which prevent them from being jarred when we run or jump. They are placed one on another in such a manner that the openings in them form a kind of tunnel or canal through which the spinal cord passes to join the brain.

The spinal cord is a big round bundle of nerves fixed tightly together and surrounded by three sheaths. Like the brain, the spinal cord is a most delicate organ, and that is why it has been placed so carefully inside the *vertebræ*, where it is comparatively safe from injury.

At the upper part of the skeleton there is a sort of cage of bones. This cage is formed by twelve of the spine-bones at the back, by twelve ribs at each side, and by the flat breast-bone in front. The ribs curve forward from the spine to the breast-bone, and the middle ribs are longer than those at the top and bottom. This bony cage is covered with muscles and skin, and is

known as the chest, or thorax. In the cavity of the chest, safe from outside harm, are the heart, lungs, and other important organs.

At the lower end of the spine is another cavity, called the pelvic cavity because it lies in the basin-shaped bony ring called the pelvis.

The pelvis is formed at the back by the sacrum or rump-bone, with another little bone, which in animals forms the tail; but in human beings it is very small. These two bones are placed at the lower end of the spine. The sides and front of the pelvis are formed by the big haunch-bones, which join each other in front, and join the sacrum on each side behind; these are flat and wing-like, and have round edges.



SECTION OF THE HUMAN BODY SHOWING POSITION OF THE SPINAL COLUMN (a).

We have now heard of three cavities or hollow spaces inside the skeleton—the cavity of the skull, of the chest, and of the pelvis. Above the pelvis is still another, the abdominal cavity, which contains the stomach and other organs.

If we look at a skeleton, we see the rib-cage above and the pelvis-bones below; but in the place where the abdomen is, we only see the spine at the back and the haunch-bones on each side of its lower part. There is no bony framework to support the front and side walls of the abdomen. These abdominal walls are made of large, flat muscles placed one on top of another. They stretch from the ribs and breast-bone above to

the top of the haunch-bones below, and to the spine behind.

The upper part of the abdominal cavity is separated from the chest-cavity by a big, flat, arch-shaped muscle called the diaphragm, or midriff. This muscle plays a most important part in our breathing.

When we speak of our limbs we mean our arms and legs. The upper limbs consist of the shoulder, the arm, the forearm, and the hand. The arms are joined to the rest of the skeleton by means of the shoulder-blades.

The shoulder-blades, or scapulas, are two big, three-sided bones placed one on each side of the rib-cage, so as to lie flat against its back. Above the ribs a short curved bone passes forward from the shoulder-blade on each side to join the top of the breast-bone. These are the collar-bones, or clavicles. The collar-bone and the shoulder-blade on each side join to form the shoulder.

Underneath the shoulder is the shoulder-joint, where the big arm-bone is fixed to the shoulder-blade in a sort of socket.

The arm, which extends from the shoulder to the wrist, is formed of several bones. The upper arm-bone, or humerus, is joined to the shoulder-blade, and reaches to the elbow. The shoulder-joint allows the upper arm to move freely backward and forward and, to a less extent, round and round. The forearm consists of two bones, the radius on the outer side where the thumb is placed, and the ulna on the inner side extending from the elbow to the wrist. The elbow-joint is called a hinge-joint because it allows the forearm to bend and straighten only on the upper arm. There is another joint between the two bones of the forearm which enables us to turn the hand backward or forward.

The hand is joined to the forearm by the wrist-joint, which is formed so that it can bend in all directions. The hand contains numerous bones: eight little roundish bones that form the wrist, and five long bones that form the palm, to which are joined the three bones of each finger, and two bones that form the thumb. A very important movement of the thumb is that which, in connection with the movement of the fingers, enables us to take hold of things. No animals except men and monkeys have this movement.

The lower limbs consist of the hips, the thighs, the legs, and the feet.

The hips are formed by the two haunch-bones, which, with the sacrum and coccyx behind, enclose the pelvis. The thigh-bone, or femur, is joined to the haunch-bone by a ball-and-socket joint, so called because the top of the thigh-bone is a ball that fits into a deep socket on the out-

side of the haunch-bone. In front of the knee, to protect the joint, is the knee-cap, or patella. The knee is a hinge-joint, only allowing the leg to bend and straighten on the femur with no side movement.

The lower part of the leg, like the lower part of the arm, is formed by two bones; these leg-bones are called the tibia or shin-bone, and the fibula. The leg joins the foot at the ankle, which is a hinge-joint.

Like the hand, the foot contains many bones: seven roundish bones, which correspond to the wrist and form the heel-bone and the ankle, and five long bones forming the framework of the foot, to which are joined the bones of the five toes, each of them having three bones except the big toe, which has two. The joints of the toes do not allow such free movement as do the finger-joints.

ORGANS OF DIGESTION—FOOD

LET us now consider the wonderful manner in which the food we eat and drink is changed into blood, flesh, and bone. That process is called digestion.

We know that everything that lives, both in the animal and in the vegetable world, requires food of some kind.

Food should be taken regularly. When our bodies want food, we have a feeling that is called hunger. This feeling is common to all animals, and causes them to seek for food.

We take nourishment in two forms: in solid form, such as meat and bread; and in liquid form, such as water, milk, and soup.

We need food to nourish our bodies, and, when they are young, to make them grow; to keep our bodies warm; to supply strength to work, like coal in a steam-engine; and to repair or mend the waste of our bodies.

The different organs of the body work so hard that they are always wearing themselves away, and half the food we take is retained by the body to repair this wear.

As our foodstuffs have to be body-makers, body-warmers, body-drivers, and body-repairers, they have to be composed of several different kinds. With the exception of bread, also of milk, which contains all that is required in the way of nourishment for young children and persons who are ill, no one food contains all the properties in just the right proportions for our needs; that is why man has to take different kinds of food in order to vary his nourishment.

On the earth, in the earth, under the earth, and in the air, are the materials of which our food is

made. But most of these materials have to be changed before they are fit for us to eat.

Our food consists of three general kinds—animal, vegetable, and inorganic. Animal food is the flesh or product of an animal, and includes beef, mutton, chicken, fish, eggs, milk, etc. The hay and grass that we see cattle and sheep eating is changed through the process of digestion into meat, which we eat as beef or mutton. Meat strengthens the body and is principally flesh-forming. In cows some of the grass and hay which they eat is changed into milk. Vegetable food is produced from plants. Bread, potatoes, rice, sugar, tea, coffee, peas, beans, cabbage, lettuce, and numerous other things, all come from plants. Vegetable food strengthens and warms the body.

Inorganic food is food that has never had life, and is not derived from animals or plants. The most important inorganic food is water, which is required by all animals and plants; without water to drink, in one form or another, they would die. Salt is a mineral food. We require salt in small quantities, and so do animals and plants.

Our bodies are made up of various elements. As these elements are always being used up, they require constant renewing by our food. Now, there are four principal elements which it is necessary that the body should take in to renew what is being consumed—carbon, oxygen, hydrogen, and nitrogen.

The body gets most of its oxygen from the air that it breathes through the lungs. Some of it also enters in the food.

The carbon and hydrogen are contained chiefly in starchy foods, such as bread, rice, and sugar, and also in fats, which include butter. The reason that fats are so heating is that they contain a good deal of carbon. This combines with oxygen in the tissues of the body, and in doing so gives rise to heat, in the same way that coal combines with oxygen when a fire is kindled.

The other important element which is absolutely necessary for animals is nitrogen. Nitrogen exists in a pure state as a gas in the air, but men and animals cannot obtain it for themselves from the air. They must get it by eating food that contains nitrogen. This food forms the chief part of meat, which is the flesh of animals, and is therefore flesh-making. Nitrogen is also contained in certain plants, such as peas and beans. But all our nitrogenous food comes to us in the first place from plant-life, on which most animals live. Too much nitrogen is not desirable, and so we should beware of eating too much meat, as many are prone to do, fancying that it makes them strong. This is not the case.

THE BLOOD AND THE HEART

THE blood is a red liquid thicker than water. When blood is looked at through a strong microscope, it is seen to consist of a clear yellow liquid in which float a quantity of small cells. These are called corpuscles, and are like very tiny round lumps of red jelly. They are so numerous that they cause the blood to appear red.

In the blood are both red and white corpuscles, and they are so small that it is impossible to see them without the help of a strong microscope. There are so many of them that when we prick our finger and lose a little drop of blood we lose about five million red corpuscles and eight thousand white ones.

The work the red corpuscles do is to convey oxygen—that gas on which all life depends—from the lungs into every cell and tissue of the body.

The white corpuscles are far fewer in number. Their work is to defend our bodies against the poisonous microbes of disease by removing them from the blood. They also help in making the new flesh which forms to heal a wound, and which later on becomes a scar.

We know that some liquids can dissolve solids and gases. The food that circulates in the blood is dissolved in it, just as salt is dissolved in seawater. The blood corpuscles, however, are not dissolved, but float about in it like so many tiny fishes.

The circulation of the blood is its constant movement round and round within our bodies, from the heart to the top of the head, to the tips of the toes, and back again to the heart.

The principal organs that are employed in the circulation of the blood are the heart, the lungs, the arteries, the veins, and the capillaries.

The circulation of the blood has three chief uses: it brings fresh air from the lungs to the body, and takes the bad air from the body to the lungs; it carries food from the stomach and intestines all over the body; and when perfect it keeps all of the body at the proper degree of warmth.

Arteries are the tubes or vessels that carry the fresh blood away from the heart and distribute it to the different parts of the body. They are generally placed well below the surface, but some of them can be plainly felt beating under the skin.

The main artery starts from the left side of the heart, and it has large branches which run to the arms and neck and head. It then passes down the body in front of the spine, giving off branches to the organs and muscles of the body.

It finishes by dividing into two branches, one of which goes to each leg.

Veins are tubes or vessels which bring the used-up blood back to the heart from all parts of the body. This blood is then pumped into the lungs, where it is purified; from the lungs it passes again into the heart, whence it is pumped back into the arteries, to start afresh on the round journey. This is the process of the circulation of the blood, and it goes on so long as we are alive.

When the arteries become so small and fine that they cannot be seen with the naked eye, they are called capillaries. Capillary is a Latin word, meaning a hair. These tiny blood-vessels are called capillaries because they are as fine as hairs. These capillaries form a network and connect the small veins with the ends of the arteries. They are nearer to the surface of the body than the arteries, and, like the arteries, the nearer they are to the heart the larger they are.

The blood which the veins contain is of a dark red color; it is called venous blood.

The artery walls are of a strong elastic kind of tissue which assists in driving the blood along; the walls of the veins are made of thinner tissues than those of the arteries, and are not so elastic.

The walls of the capillaries are very thin indeed, and have no elastic tissue or muscle in them. They are so thin that the fluid part of the blood in them soaks through into little spaces, called lymph-spaces, which surround nearly all the cells of the body and keep them constantly soaked in lymph. This lymph is a colorless fluid containing the altered food which the blood brings from the digestive organs. The lymph-spaces are joined together by little tubes called lymph-vessels, or lymphatics.

The heart, which pumps the blood through the body, is a kind of fleshy bag, made of muscle, about the size of a person's fist, placed somewhat to the left of the chest, between the lungs. It is protected on the outside by the ribs.

In order that the blood can be forced or pumped out of the heart, this organ opens and contracts regularly, and by so doing produces the heart-beats which we can feel when we put our hand over our heart. The muscle of the heart is not like the muscles that move our arms and legs. Those we can move or keep still, as we like, but the heart beats constantly so long as we are alive.

The heart is formed of four hollow parts or cavities. The upper are called the right and left auricles; and the two lower parts, the right and left ventricles.

Between the auricles and the ventricles, and at

the bottom of the big arteries that spring from the heart, are placed valves. These are curtains made of tough muscular tissue, which, when the heart contracts, only allow the blood to flow through them in one direction. Their action is somewhat like that of trap-doors opened by the blood streaming through at each heart-beat and swinging back into position to prevent the blood from falling back into the heart.

The blood starts on its journey from the heart by passing through the left auricle and left ventricle into the great artery, the aorta, whence it goes into the smaller arteries and into the capillaries. It is by means of the capillaries that the small endings of the arteries join the small beginnings of the veins.

When the blood is passing through the capillaries, all the nourishment in it that is required, and is suitable to make good the waste of the body, passes out through their thin walls into the lymph-spaces and is absorbed through the tissues into the different parts. The impurities rejected by the tissues pass from these spaces into the blood, which, as it now flows into the veins from the capillaries, is no longer bright red in color; it has become dark, since the oxygen that helped to give the blood its bright coloring has been absorbed.

The venous blood—the dark-red used-up blood coming from every part—is emptied by the large veins into the right auricle, which presses it onward into the right ventricle. This in its turn presses it through the big blood-vessels to the lungs. There it is purified and becomes again red in color owing to its coming in contact in the lungs with the fresh air, the oxygen, which is taken into the body by the process of breathing.

This blood is then carried back into the heart by the pulmonary veins, which pour it into the left auricle, and thence it passes into the left ventricle, thus completing the round of the circulation. The blood is now ready to be pumped afresh all through the body.

Starting on its journey from the heart, the blood flows quicker in the arteries than in the veins. The force of the heart-beat is also helped by the elasticity of the arteries.

About a wineglassful of blood is discharged out of the heart every time the heart beats. It is sent out quickly, in jets. By placing a finger on the thumb side of the wrist we shall feel a slight movement that is called the pulse. It is caused by the jets of the blood flowing through the artery from the heart.

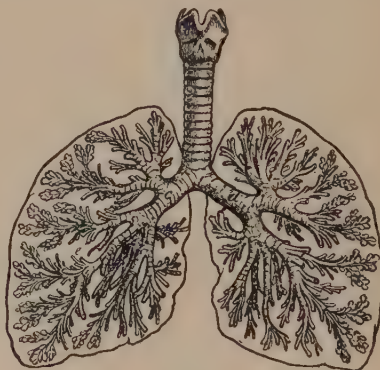
The pulse of an average grown person in good health beats about 72 times a minute. By that is meant that if we take out a watch and look at

the minute-hand, we ought to count 72 beats of the heart during that time; but some healthy people's pulses are as slow as 60, and others as fast as 80. Children's pulses beat rather faster than grown-up people's. When it is said that any one has a good circulation, it means that the heart is doing its work properly.

THE LUNGS AND BREATHING

BREATHING, or respiration, is the taking of air into the body and sending it out again. The lungs are the organs by which we inhale the fresh air into our body, and exhale the bad, used-up air.

The lungs are placed in the chest inside the ribs. They lie one on each side of the backbone.



THE LUNGS AND THE BRONCHI.

They are like two large bellows, and are joined together in the middle by two hollow tubes, the bronchial tubes, or the bronchi. These tubes unite to form the windpipe, or trachea, which passes up the front of the neck and opens into the back of the mouth behind the tongue.

The lungs are said to be like bellows because they take in and breathe out air; if, however, we could see them, they would look somewhat like sponges containing air instead of water. The lungs are elastic, which means that they expand or get bigger when they are filled with air, and contract again when they are empty.

The air passes down into the lungs through the nostrils and so becomes slightly warmed; and the little hairs with which the nostrils are lined prevent the dust we inhale from going farther. It is well to remember that the nose is meant to breathe with, and that the mouth is made for eating and talking.

After coming in through the nostrils or mouth, the air next goes into the throat, the hollow

space at the back of the mouth. The top or roof of the mouth is called the palate. Far back in the mouth, at the entrance to the throat, is a little fleshy mass which hangs down from the palate. This is the uvula. At the sides of the throat are two fleshy lumps called the tonsils.

The throat, which is also called the pharynx, leads into two tubes. One is the gullet, or food-pipe, which lies at the back. In front of it is the windpipe, or trachea. The throat does not lead into the trachea, but into a sort of box at the top of it, which is called the larynx, or the voice-box. There it is that sounds such as speaking, laughing, and coughing are formed. The larynx, which is made of cartilage, contains two tightly stretched cords which close its upper part, except for a chink between them. Through this chink the air rushes and forms the voice, so the cords are called the vocal cords. The throat and lips and tongue and teeth also assist in the pronunciation and sounding of words when we speak or sing.

The top of the larynx is very sensitive to any food that may lodge there, and causes one to cough to get rid of it. The food is prevented from falling into the larynx by the sharp closing of the vocal cords every time we swallow anything. This shuts up the air-chink in the larynx.

The air passes through the larynx into the windpipe, which connects it with the lungs. The windpipe divides into the two bronchial tubes. Each of these tubes goes into a lung.

The bronchial tubes are divided and subdivided into a quantity of smaller tubes. Every one of the smaller tubes ends in a sort of blind alley, with little bays all round it. These are the air-cells, and it is through them that the oxygen in the air passes through into the little blood-vessels, which are the branches of the bigger ones that bring the blood from the heart to the lungs.

The lungs expand every time we enlarge our chest by means of certain muscles. Chief among these is the diaphragm, which is a flat muscle which separates the chest or thorax from the abdomen. Every time we take in air, the diaphragm contracts, its dome becomes flatter, and the lungs increase in size and follow it downward. It is drawn low down to make more room inside the body so that we can take in a deeper breath. When we breathe out air, the diaphragm rises again, and the lungs become smaller.

Naturally, the diaphragm ought to have as much free play as possible, so that it can do the work allotted to it. That is one reason why

tight lacing is so hurtful to girls and women, since it hinders the breathing-organs from doing their work properly. When that part of the body which includes the waist and chest (containing the diaphragm and lungs) is tightly laced up, it cannot possibly expand and contract as it should.

We see that the air enters and leaves the lungs by our drawing it in and letting it out. The two movements by which this double action is performed are called inspiration and expiration. With inspiration, which is the drawing in of the breath, the chest swells out, and becomes filled with fresh air. With expiration, the chest contracts to its former size, and the breath escapes.

In order that the lungs may purify the blood to the best of their power, the air they take in ought to be fresh, pure air, as bad air is one of the worst enemies of the body.

THE MUSCLES AND THEIR WORK

THE body and all the different limbs move by means of the muscles, or muscular power. Muscles are the lean red flesh of the body. The lean meat of beef, mutton, or pork is the muscle of cattle, sheep, or pigs. This flesh or muscle covers the bones of the body; next to it comes a layer of fat, and then the skin.

Flesh is composed of numberless threads or fibers, just as a bit of worsted or sewing-silk is made up of several threads or strands. These fibers, joined together in bundles, form most of the different muscles of the body. Each separate muscle or bundle of fibers is wrapped up in a fine skin or membrane, much as sausage-meat is enclosed in a skin.

The muscles are attached very firmly to the bones, which they move by strong cords called tendons, or sinews. These cords are made of tough fibrous tissue, just as the ligaments are. But the difference between them is that ligaments bind together the two bones that form a joint, while tendons join the muscles to the bones which they move. Most tendons are round and white and shiny; some few are flat and broad.

Muscles are able to move the bones to which they are fixed, because they have the power of contracting. When a muscle contracts it becomes shorter and thicker.

There are two kinds of muscles, voluntary and involuntary. The voluntary muscles are those that are attached to the bones and that enable us to move the different parts of our body, such as the head, legs, arms, fingers, etc.



MUSCLES OF THE HUMAN BODY.

These do their work by the orders they receive from the brain; since our will-power, the power that gives us control over our bodies, is lodged in the brain. They are called voluntary because we move them of our own free will—because we wish to move them. For instance, if we want to pick up a book on the table before us, we stretch out our hand. In doing this the muscles at the back of the arm contract or shorten and so make our arm straight. Then our finger-muscles contract and bend the fingers so that we grasp the book. Both our elbow and finger joints have been used, and we also employ other muscles to move our wrist and shoulder joints. It is necessary to use all these muscles and joints to pick up a book quickly and neatly.

Nearly all the voluntary muscles of the body are fixed at each end to a different bone, because they are used for moving the bones. A very few muscles are fixed at one end to some other structure. The eyes, for instance, are moved by the contraction of little muscles fixed to the sides of the eyeballs. There is an important muscle that has one end quite free; that is the tongue, which is fixed at its root to a little bone in the throat, but its front part is free in the mouth. If it were not, we could not talk or eat properly.

The principal muscle of the arm is the biceps muscle. This we can feel forming a lump on the arm. This muscle is fastened by two strings or sinews to the shoulder-blade, and by another sinew to a bone in the lower arm, just below the elbow-joint. When the biceps muscle contracts, it pulls up the lower arm and hand. In the same way all the movements of our hands, arms, legs, head, and body are performed.

We never have all our muscles slack or relaxed at one time. Even when we are standing up or sitting down there are many muscles in the body or legs braced up to just the right degree of tightness to prevent us from falling down in a heap. In walking, very many muscles are contracted, one after the other, to take us along at just the pace at which we want to go; if they do not all do their duty properly we stumble or walk crookedly. The reason why they act so well together is that they are all governed by the nerves which run to them from the brain.

But we may say: "When we walk or stand we do not think about it; we keep our balance naturally, without troubling our brain to help us." That is partly true, but we must remember that when we were babies we had to learn to stand and walk. Our muscles had to be trained, and our brain thought of nothing but how to balance our body when we were having those baby lessons. Now our muscles have been so well trained

that they require very little of our conscious attention. That is to say, our brain can keep them working properly and yet let us go on thinking or talking at the same time.

The involuntary muscles are those muscles not under the control of the will. They belong to the internal organs, those wonderful organs that do their work day and night without any direction or control on our part. We do not know they are working, and we can neither start them working nor stop them.

The muscle of the heart, which causes it to beat, the muscles in the walls of the stomach and intestines, which churn up the food and drive it along, are some of the involuntary muscles. What a wonderful thought it is that, waking or sleeping, certain parts of our body are always moving, always at work, never at rest!

THE BRAIN AND THE NERVES

LET us now learn something about the most wonderful of all the bodily organs—the brain, which is the organ of the mind. It is by means of the brain that we are able to think, to will, to feel, to see, to hear, to move; for the brain is the power that sets to work all the different parts of the body.

The brain is like a foreman, the different organs of the body being the workmen. Each part, like each workman, has its own special work to do, and over them all, to direct them, to guide them, is the brain.

The brain is placed in the skull, and is divided into two parts. In the upper and front part is the greater brain, the cerebrum; in the lower and back part is the lesser brain, the cerebellum.

The substance of the brain is a mass of soft white and gray matter. The outside is not smooth, but has deep curved grooves all over it which divide it up into different parts or regions. Each region of the brain has to control a special part of the body.

The chief duties the brain has to perform are the duties of the mind, or intellect, and the will. These include thinking, reasoning, remembering, and deciding what to do and say. They are the highest duties of the brain, and mankind possess them to a far greater degree than do any of the lower animals. It is this fact that makes us responsible for our actions; the brain gives us the power of knowing right from wrong.

The brain has also to govern or control the movements of every part of the body, that is to say, the action of all the muscles. It does this by sending messages to them through the nerves.

Likewise it controls all the vital functions of the organs, such as the circulation of the blood, the breathing, the digestion, and so on. It does this through the nerves that join it to the different organs. It receives messages from all parts of the body by means of other nerves, which cause it to feel, to see, to hear, to taste, and to smell, so as to keep its owner informed of what is going on in the world round him.

The spinal cord proceeds from the brain, passes through the center of the backbone, and ends at the bottom of the spine.

The spinal cord consists of a thick round bundle of nerves bound closely together. It is made of the same substance as the brain. As it runs down the spine, the nerves of which it is composed branch off in pairs, one on each side, in regular order. These nerves run to all parts of the body and limbs, and thus connect them with the brain. The spinal cord gets thinner and thinner at its lower end, and finishes by splitting into a number of nerves which go to the legs, just as a rope sometimes has a frayed end with a lot of separate strands.

There are little thready formations all over the body, and they run inward to join the cord in the spine. In this way they pass up to the brain. These threads consist of the same matter as the spinal cord. They are called nerves. Where they enter the spinal cord they are as thick as very thick string, but in the muscles and skin to which they run, they divide up into a number of fine threads, so that their endings are finer than hairs.

We have separate nerves belonging to every inch of the body. Each one of these nerves has its own work to do—its share in the total nerve-service of conveying messages to the brain from all parts of the body, and bringing back orders from the brain to every muscle and every organ.

The delicate ends of the nerves are to be found all over the body; we cannot touch with the point of a needle any portion of the skin that does not contain a nerve-ending. They give information to the brain of what is taking place in the part where they are distributed. For instance, with the end of the finger we can tell whether anything we touch is rough or smooth, hot or cold. Nerve-endings in the ear, eye, tongue, or nose send communications to the brain as to hearing, sight, taste, and smell.

The nerves along which such messages come are called the nerves of sense. Acting on the information which they supply, the brain at once sends an order to any muscle or set of muscles by other nerves which run to them, and so cause them to move. These nerves are called the nerves of motion or movement.

It is only when the brain is not working properly that we realize the power it has over the body. For instance, after a serious injury to the spine a person is sometimes unable to move his body and legs, and loses all feeling in them; this is owing to the nerves no longer being in direct communication with the brain.

Just the same thing happens when we hear that telegraph communication has broken down in certain places, when, possibly owing to storms, the telegraph wires become disconnected from the electric current. The result is that though people may send as many messages as they like, they can get no reply. So it is with our body. If the brain is to do its work efficiently, the nervous system must be connected and in complete working order, to enable all parts to co-operate.

We all know what it is to feel tired, and we also know that after a good sleep the weary feeling disappears; we lose the aches and pains out of our head and back and legs. When we are asleep our brain also is partially resting, because it is not obliged to receive and send the numerous messages that it does when we are up and doing; though, even during sleep, the brain is not really at rest, for it has to keep our hearts going, and our respiratory and digestive organs as well.

THE FIVE SENSES

THE sense of feeling is located in the nerves. These have already been described.

The sense of taste is in the mouth, because the nerves of taste are placed in the tongue, and in the back part of the roof of the mouth which is called the palate.

The saliva which collects in the mouth and which is made from the blood in the salivary glands, besides assisting us to digest our food, also helps the tongue to exercise the power of taste, by dissolving the "tasty" matter in the food.

The tongue has other work to do besides tasting; it helps us in speaking and it enables us to pronounce our words.

The nerves of smell are in the nose, which is formed of cartilage covered by flesh and skin.

The narrow part of the nose where it joins the forehead is called the bridge. The two holes at the bottom of the nose are the nostrils. The air required for the lungs should be taken in through the nostrils, and not through the mouth.

The nerves of smell are placed in the upper part of the skin that lines the nose. They carry messages to the front part of the brain. We cannot smell everything, but only those things

from which tiny particles come off and pass up into our noses so as to reach the nerves of smell. These nerves project downward in innumerable fine hair-like brushes into the upper part of the nostrils, and are connected above with the under surface of the brain.

The sense of smell is very highly developed in animals that have to search for their food. Every animal has its own peculiar scent; this is known and serves as a clue to other creatures who are hunting for food. It is very wonderful that an animal, such as a fox, running a great distance over dry or wet ground, may leave a faint scent, and thus enable the hounds to track it.

Domestic animals that are fed daily by men, and do not have to provide food for themselves, lose their keen sense of smell; at the same time they generally take the precaution of sniffing the food given them before they taste it, and will not partake of it if they do not like the scent.

Our sense of smell helps us to taste our food. Both smell and taste are very useful in digestion, because our nose and tongue send messages to the brain when pleasant food is entering the mouth. The brain sends messages to the glands that form the digestive juices in the mouth and stomach, and these messages tell them to make an extra supply at once to help digest the food.

It is difficult to understand perfectly how hearing and sight act; in order to do so we must know something about both sound and light.

We all know that the sea is never at rest, that the water in it is always moving up and down and to and fro in waves; and also that when a stone is thrown into a pond, when the water is still, little waves or ripples spread out in circles all around where it sank.

In the same way sound and light are caused by waves and ripples spreading through the air from the places or objects where they are produced.

But there is a great difference between sound-waves and light-waves. Sound needs air or water or some other form of matter through which to travel, or else we cannot hear it; but light-waves travel many times faster than sound-waves, and will pass through space where there is no air. All the light from the sun comes in little waves through many millions of miles of space.

These sound-waves and light-waves, which are called vibrations, hit against every part of our bodies, but there are only special parts of the body that can feel them and send messages to the brain, which cause the sensations of sound and light.

The nerves in the ear are made so that they can receive sound-waves, and the nerves at the

back of the eye are formed to perceive light and color waves. In other words, we hear with our ears and see with our eyes.

By means of our ears we are able to hear what others say to us, and to enjoy the beautiful and sweet sounds in the world. We are also warned by our ears of the approach of certain kinds of danger, such as a wagon or motor when we are crossing the street.

The ears consist of three principal parts: the outer, the middle, and the inner ear.

The outer ear, which is placed outside the head, is made of gristle. It is so formed that it catches noises and sounds such as talking, laughing, singing, etc., and conveys them through a tube to the middle, and then to the inner ear, where are located the nerves of hearing which carry the sound-messages to the brain. We know how the wire of a telephone carries sound over long distances; and we may say that the ear is the brain's telephone instrument and that the nerves are the wires.

There is a passage that joins the outer ear to the middle ear. The end of this passage is closed by a thin skin or membrane, called the drum of the ear. Beyond the drum lies the middle ear.

From the middle ear a passage leads to the throat, and through this air passes up into the ear. The nerve by which sound is conveyed from the ear to the brain is called the auditory nerve, or hearing nerve.

A musical drum has stretched tightly over each end a sheet of strong skin, or membrane. So long as this has no hole in it, when it is struck the drum makes a loud sound. But if there is a hole, no matter how small, the drum cannot give forth the true sound. That is what happens with the drums of our ears. When the delicate membrane which answers to that in the musical drum is pierced, the ear is no longer able to do its work, and we become deaf. Deafness is a great disadvantage, and one should guard the sense of hearing as carefully as possible.

The organs of sight are the eyes, which are placed in the face, in bony sockets on the outside part of the skull.

The eyes receive every image that we see, and send it to the brain by means of the two nerves of sight called the optic nerves. These enable us to distinguish between light and darkness. Also, they keep us informed of the size and color and shape of all the objects round us.

The eyeball, which is round, consists practically of two parts—a front portion and a bigger back portion. In a person's face we see only the small front part. The round, glassy-looking part, surrounded by the white of the eye, through

which we see, is called the cornea; behind the cornea is a round curtain called the iris, brown, gray, or blue, which gives the color to the eyes. In the center of this curtain is a dark hole, called the pupil. Through this the light enters the eye.

Inside the eyeball is a clear fluid, and in front of it a little oval-shaped transparent body called the lens. These are in front of the retina, which is a fine and delicate membrane spread out at the back of the eye. The light-waves enter the front part of the eye and strike against the retina, which is sensitive to them because of the tiny nerves it contains. The retina is joined to the nerve of sight, called the optic nerve, and through this it telegraphs to the brain the pictures that have been formed on it. This causes the sensation of sight.

The eyes are protected by the eyelids. We have an upper and lower eyelid. These are formed of gristle covered with skin. The upper one we can move up and down at will. If we wish to go to sleep, we let down the eyelid over the eyes to shut out the light. At times, when we are very tired and our bodies badly need rest, our eyelids close almost against our wish.

The eyelids are edged with short hairs, called eyelashes. These are for protection, and often they prevent dust, insects, etc., from getting into the eyes.

We all know what tears are—those drops of salt water that come into our eyes and run down our cheeks when we cry. Tears are formed from the blood by a little organ just above the outer side of the eye, called the tear-gland.

Our eyes require great care, since they are such delicate organs. We usually know if we have anything the matter with them, by the intense pain we suffer. Even when an eyelash or a tiny bit of dust gets into the eye, we feel pain. The water in the tear-gland then comes to our assistance; it fills the eye in order to wash out the irritating substance.

Savage nations have much keener eyesight and sense of hearing than we who live in civilized countries and cities. It is because they use these senses to a far greater extent than we do. In their search for animal food they are always on the lookout for some sign, no matter how small, by which to track their prey. In like manner their sense of hearing is developed. From different slight sounds, such as the distant footfall of an animal, or the flap of a bird's wing, they can tell what kind of animal or bird they are tracking, and where it is. We cannot do this to the same extent because we do not so much exercise these powers; we have little need of them, since we are not obliged to hunt for our daily

food. In other ways, however, they are still preserved and developed among civilized people; for example, great painters and great musicians have been able, in a different way, to train to the highest uses their powers of seeing and hearing.

THE SKIN

We have now to learn something of the covering of the body—the skin. This protects the muscles, blood-vessels, and nerves, which are beneath it, and though it is tight-fitting it grows with the body.

The skin varies in color in human beings according to their race or their nationality. Northern people in general have white skins, whereas those races that belong to the tropics, as the African negroes, the Hottentots, the East Indians, are very dark-skinned, many of them being almost black. Some of the native races who inhabit the continent of Asia, such as the Chinese and the Japanese, have skins of a yellowish hue.

All living things, birds, beasts, and fishes, have a skin, an outer covering of some kind, which is specially suited for their protection and requirements. How these skins differ in appearance! The thick, tough skin or hide of the elephant that some of us have seen at a circus or in a zoo; the scaly skins of fishes; the covering of the bodies of insects; the hard armor that covers beetles and lobsters—among these great differences are seen.

The shell found on the beach has been at one time the covering for a little soft fish, which made the shell out of its food, just as our bodies make hard bone out of our food.

Most four-legged animals, such as horses, dogs, cows, and tigers, possess an extra covering in the form of hair. With some animals, such as bears, cats, and rabbits, the hair coat is very thick, and we call it fur. Sheep have thick curly hair that we call wool. Instead of hair, birds have feathers growing all over their skins.

As our bodies are not provided by Nature with an extra covering of fur or feathers, we have to wear clothes, to keep ourselves warm. These clothes are made of animal or vegetable products. The hides of animals provide the leather we use for our boots and shoes. Flannel and other kinds of cloth are prepared from the wool of sheep; silk is woven from the silk spun by the silkworm; while cotton is produced from the seed-pods of the cotton-plant, and linen from the fibers of a plant called flax.

We know that skin is formed of numberless small parts called cells, and that when a great

number of these cells join together, they form tissue. The tissues of the skin include the cells that form it, and also the sweat-glands.

We have two layers of skin. The outer one that we can touch and see is called the epidermis; the inner one, the dermis. The epidermis is composed of countless small scales of thick skin laid one against another, somewhat like the scales of a fish, or the tiles in a floor. As there are neither blood-vessels nor nerves in the epidermis, we may slightly graze it or rub it without feeling pain or losing blood.

The lower skin, the dermis, consists of somewhat bigger, rounder cells, and among them run small blood-vessels and nerves, so that if it is cut it bleeds; and if anything hurts the lower skin we feel it at once. Even when a tiny insect thrusts its sharp little sting into us, we feel the prick. It is in the skin that the nerve-endings are placed, and these give the skin the power of feeling when anything touches or hurts it.

Some reptiles, such as snakes, shed their skin every year. A new skin grows inside the old one and gradually pushes it off; then the snake wriggles out. This is how it happens that the whole skin of a snake is sometimes picked up in the fields or woods. We also shed our outer skin, but not all in one piece as does the snake. We shed ours in the form of a fine dust. Day by day some of the cells of the outer skin die and are rubbed away, and their place is taken by fresh ones from underneath. These young cells increase by dividing in two again and again. The new cells grow up toward the surface and push away the old ones, which then drop off.

This is an example of how the body repairs itself. We can study it easily in the skin, but we must remember that the cells in every part of the body are likewise constantly being renewed. The material that makes the new cells is the food.

The skin has a very important share in carrying away waste matter, in the form of sweat, or perspiration. This is discharged through small

holes in the skin, so tiny that most of them are invisible. These holes are called pores. They are the openings or mouths of little tubes, called sweat-glands, placed in the skin. They act as drain-pipes to the body, since they carry off waste matter as already told.

We begin to realize what a number we have of these little tubes when we hear that there are over five thousand of them in the tip of one of our fingers, and that if all the sweat-glands belonging to the body were joined together they would form a tube about four miles in length.

We all know what is meant by sweat. We see it on our faces when we are very hot. It looks like drops of water. Sweat is some of the refuse which the blood has picked up in its journey through the body, just as a river carries along on its waters all kinds of waste and rubbish. This soaks through the thin sides of the blood-vessels into the sweat-glands, whence it oozes out through the pores of the skin.

Day and night, unknown to us, the sweat-glands are busy separating this watery fluid from the blood; and as more than a pint of sweat passes out of the skin in the course of twenty-four hours, these little drain-pipes have a busy time. It is only when we are perspiring very freely that the sweat can be seen. As a rule it passes off into the air in the form of invisible vapor. Besides the sweat-glands, there are other glands in the skin that form an oily matter from the blood in order to keep our skin soft and supple.

We now understand, apart from its being the covering of the body, how important the skin is in keeping our bodies well and healthy.

From the foregoing pages we learn that our bodies are indeed wonderful and complex machines; and strong as the body in health may be, it is yet very delicately formed. Therefore no pains or trouble should be considered too great to keep our bodies in perfect condition; for good health is the greatest blessing a person can possess.

THE HUMAN EYE

WHEN we examine the eye, the first thing we notice is that the front of it is transparent. This round, transparent part in front is called the cornea, which really means the horny thing. If we look very carefully at it, we shall see that it bulges forward somewhat. The curve of it is not quite the same as the general curve of the eyeball. This shape of the cornea is very im-

portant because of its effect on the rays of light that enter it. It acts just like the curved surface of the eye-cell of a leaf.

The first and greatest business of the cornea is to be perfectly transparent. It contains, therefore, no blood-vessels, small or great; it would not do to have red or white blood-cells in the cornea interfering with the passage of light. But

the cornea is alive and must be fed, and it is supplied by materials that pass to it through the walls of the tiny blood-vessels that we find all round its edge. The cornea is well supplied with nerves, nearly all of which run to its front surface, in order that it shall be very sensitive.

This is necessary so that the least particle of dust, or anything else that would injure it, shall be felt and wiped away by the eyelids and the tears. Only too often, however, a person gets what he calls a "speck" in his eye, and then there is a great risk that when the cornea recovers from the injury the injured place will be opaque for the rest of his days.

THE CORNEA OF THE EYE AND ITS WONDERFUL FORMATION

It is well for us to understand how important and wonderful the cornea of the eye is. All the light we see by must pass through it; yet it is a living thing, with all the needs and delicacy of a living thing—very different from a curved piece of glass. Lastly, it is very much exposed, though, as we know, the eyelid, eyelashes, eyebrow, and the bony wall around the eye do their best to protect it.

All round its edge the cornea passes into the white, thick, strong coat of the eyeball; indeed, the cornea is really a special part of this strong outer coat of the eyeball that has been made transparent, and has been made to bulge forward a little in order to help in focusing the light.

Now, when we look at any one's eye we see something through the transparent cornea. We see a round, colored ring with a black hole, small or large, in the middle of it. The colored part is called the iris, and it is a ring of muscle with a hole in the middle of it, which is the pupil. This looks black because it is really the hole leading into the dark chamber, or inside of the eye, which is like the inside of a camera. If we could be shown an eye cut through sideways, we should see that there is quite a large space between the cornea and the front of the iris. This space is filled with a watery fluid, and the light has to pass through this fluid before it is able to reach the pupil.

THE PUPIL OF THE EYE, THAT ENLARGES IN A DIM LIGHT

THE business of the iris is to regulate the size of the pupil. The less the amount of light, the larger must the pupil be; and the more the light,

the smaller the pupil. So when a person goes from darkness into light, or when the eyes are opened in a bright light, any one may see that the pupil gets smaller.

All the color of the eye is due to the iris. The color is not to be found at all in the muscle-fibers that make the iris; they are just like other muscle-fibers, and are the same in everybody. But both on the back and front of the iris there is a layer of cells, which may or may not contain a certain amount of pigment, or coloring-matter.

If we pass through the door in the iris, we find a beautiful transparent thing called the lens of the eye. It is a genuine lens, just like the lens of an ordinary magnifying-glass, and it is of the same shape, convex, or slightly bulging, on both sides. It helps to bend the rays of light entering the eye, just as the cornea did, and it is perfectly transparent. Unlike any lens that any man ever made, this lens, while able to do all that artificial lenses do, can do far more; for it is elastic, and can change its shape according to our need.

THE LENS OF THE EYE, THAT IS KEPT IN A LITTLE BAG

THE lens lies inside a little bag, and that bag has little fibers attached to it all round, which can be pulled upon by tiny slips of muscle inside the eye. When the bag is pulled upon in this way all round, the lens inside it is made flatter. When the muscles stop acting and the pulling ceases, the lens is free to bulge out again if it is perfectly elastic.

It is by this power of the lens that we are enabled to see clearly both at short distances and at long distances. Now, as every one knows, in the case of an ordinary camera it is necessary to focus the light properly if the picture to be taken is to be sharply defined on the plate. In this case, and in all other cases where men use artificial lenses—as, for instance, in the microscope and the telescope—the same method of focusing is employed, and that is to alter the distance of the lens or lenses from the place where we want the image to fall.

The method of the higher types of eye is not, as in the case of fishes, to alter the position of the lens, but to change its shape where it stands. That is why it has to be perfectly elastic, so that after it has been flattened, by having the bag in which it lies pulled upon, it can spring back perfectly to its rounder shape.

This means that the shape of the eyeball, as a whole, is very important. An eyeball may be long from back to front, and then the lens is far from

the retina, or it may be short from back to front, and then the lens is nearer the retina. If the lens be of the same shape in the two cases, one eye or both cannot be quite suited to its purpose. Thus, in consequence of the varying shapes of eyeballs, the variations in the curve of the cornea, and the variations in the shape of the lens itself, we find that there are a very large number of people whose eyes are not perfectly suited for all kinds of use.

NEAR-SIGHTEDNESS HAS NOTHING TO DO WITH THE EYE'S HEALTH

Nothing is more important than for us to understand, at the very first, that near-sightedness is not a question of the health of the eye. An eye may be healthy or sick, like any other part of the body, but what we are now considering is simply a question of the mere shape of the eye or certain parts of it. The bending of rays of light is called refraction, and so we usually speak of "errors of refraction" to describe those cases where an eye is near-sighted or far-sighted, or has some defect of that kind.

This has nothing to do with the health of the eye or of any other part of the body, except that, as we shall see, if something is not done, the rest of the body may be affected. We are to look upon the eye for the moment as a kind of optical instrument, or machine, and simply to realize that the shape of this optical instrument will affect the rays of light that pass through it, just as in the case of any other optical instrument.

It is very commonly found that the cornea is not quite regularly curved; it bulges more or less in one direction, say, from side to side, than it does in another direction, say, from top to bottom. This means that, if we are looking at a cross, the one arm of it cannot be seen sharply if the other is. As a rule, this defect in the shape of the cornea is so slight that it is not worth noticing; but sometimes it is well to wear glasses which are more curved in one direction than in another, so that the little defect is corrected. This particular error of refraction is not nearly so important as those we must now study.

WHY SOME PERSONS ARE NEAR-SIGHTED—AN INCONVENIENT DEFECT

NEAR-SIGHTEDNESS is what happens when the eyeball is rather too long from back to front. This error of refraction means that the light is focused

before it reaches the retina, and when it does reach the retina the picture it makes is rather blurred. Sometimes, also, near-sightedness may be due to the cornea being too much curved, so that it acts as too strong a lens, and the rays of light are focused too soon.

Near-sightedness is a very common defect, and is very inconvenient. A person affected with it can see anything near very clearly, while things farther off are blurred. The reason is that, when a thing is held close, the eye catches the light-rays from it as they are spreading out. If they are spreading out when they reach the eye, they are not so likely to be focused too soon; but if the thing is farther away, then the rays coming to it from the eye are not spreading out, or divergent, as we say, but are parallel, and will be too easily focused for the convenience of an eye that is too long from back to front.

The near-sighted person is at a disadvantage in recognizing people, and also in playing games. It is a nuisance to have to wear glasses to see clearly at any distance; but, on the other hand, he suffers no injury if he wears no glasses, and his eyes are very well suited for work at short distances, such as reading and writing, looking after machinery, sewing, and, indeed, nine-tenths of all the work that is done by civilized people to-day. People who are near-sighted when they are quite young, or who even are far-sighted at first—as most young children are—often become gradually more and more near-sighted until the age of, perhaps, thirty.

Some who have not really gone into the subject properly think that near-sightedness is a sort of disease of the eye, due to overuse of it, bad conditions during childhood, and so forth. Others think that it is a natural change which is bound to happen in any case; and still other people suppose that increase in near-sightedness is due to the constant use of the eye at short distances.

The truth lies somewhere between the last two opinions; each of them is probably true in part. The eye, like other parts of the body, does undergo natural changes during life, and as it gradually becomes more far-sighted after a certain age, quite apart from anything that is done to it, there is no reason why it should not become more near-sighted during the earlier years.

HOW HEALTHY EYES MAY BECOME NEAR-SIGHTED

ON the other hand, we can prove that, when the eye is used for short distances, certain muscles inside it are used in such a way as to tend to

make the eyeball longer from back to front, and therefore more near-sighted.

The reason for going carefully into this is that very few people understand the facts, and even many doctors have not properly inquired into them. Often young persons between the ages of twenty and twenty-five find that year by year they become more near-sighted; perhaps they require to use glasses for games where formerly they did not need them, and the glasses have to be made stronger and stronger; or parents find their children beginning to require glasses for near-sightedness, and every year or so the glasses have to be made stronger.

People are alarmed if they think that all this means a kind of disease of the eye. That is why every one should understand that near-sightedness is not a disease at all; that the changes which go on are natural, and that they only go on to a certain point.

More than this, it is certain that we may look upon near-sightedness in our time as a kind of adaptation to our needs—that is to say, in the case of the great majority of people who have to use their eyes at short distances. For such distances the near-sighted eye is the best that one can have; it lasts well, and does not tire.

NEAR-SIGHTED PEOPLE MAY IN TIME BECOME FAR-SIGHTED

AFTER a certain age, perhaps about forty-five, or later, the eyes, after having remained just as they were for many years, begin slowly to become far-sighted, or less near-sighted, as the case may be. But before we look at this we must return to the case of the child.

Practically all very young children are far-sighted. A certain number of them remain far-sighted as the years go on, and are still far-sighted when they begin to learn to read and write. In days gone by this was no serious matter, because people lived far more natural lives than they do now; they lived much more in the open air. Instead of constantly reading books held in the hand, they had to read the book of the distant clouds and mountains; they had to see animals or enemies at great distances, and the use of their eyes for short distances was only occasional.

THE USES FOR WHICH NATURE HAS FITTED DIFFERENT EYES

WHEN the eye is to be used at long distances, evidently the far-sighted eye has little to complain of. It is as well off as the near-sighted eye

is in the kind of life that most of us are living nowadays.

The time may yet come when, before we decide what to make of our children, we may ask ourselves the question, What has nature intended them for? Perhaps, for instance, other things being equal, we should think twice before we sent the far-sighted boy to a desk rather than to sea or to a life out of doors. Meanwhile, however, our general idea seems to be that all children are just the same, and require just the same treatment, and the far-sighted child is treated just like the other. But, whatever we do in this way, it is certainly our business to see that we do not hurt a child in the process.

The far-sighted eye, as we have said, is too short from back to front. The rays of light are not focused in time. Now, if such an eye is to be used at short distances, it will be very much strained, because the muscles inside the eye will constantly be trying to change the shape of the lens in order to make the eye focus better; in fact, the far-sighted eye requires to use the muscles inside it in all circumstances. This means that it is liable to get tired, and every far-sighted person knows what it is to get headache and eye-strain from the use of the eyes under conditions which would not be at all inconvenient or disturbing to a near-sighted person.

THE FOLLY OF MAKING CHILDREN USE THEIR EYES WRONGLY

IN our ignorance regarding children, and in the very foolish way that we pretend to educate them, we may inflict very grave injury upon them by compelling them to use far-sighted eyes for purposes to which they are not suited.

All over the country, children are straining their eyes at reading and writing. All they need is a pair of spectacles with rounded convex lenses that will help to focus the rays of light quickly, so that they are brought sharply together by the time they reach the retina at the back of these short eyes. It is the short eye, we notice, that is far-sighted, and the long eye that is near-sighted.

It is just beginning to be discovered how important this subject is; now parents know that before a child begins to go to school it should, if necessary, be equipped with suitable glasses.

THE LENS OF THE EYE THAT CEASES TO BE ELASTIC

THE far-sightedness of elderly people is due to changes that occur mainly in the lens of the eye.

The all-important elasticity of the lens becomes impaired, and it does not bulge when the pressure of its coat is removed as readily as it used to do; indeed, it becomes decidedly flatter. In extreme old age the lens loses its elasticity to such an extent that its shape cannot be changed at all.

The commonest sign that the eyes are beginning to show this change is that the person finds it more difficult to read in a dim light. It is very much better to be sensible about this and wear glasses than to try to fight against it. This does no good; on the other hand, it may do just the same kind of harm as is done to the far-sighted child that is sent to school without having glasses provided for him.

Of all the many evils from which mankind suffer, very few are more unnecessary, more easily and cheaply relieved, than those due to errors of the eye.

In old age, or sometimes before it, the lens of the eye may become opaque. Cataract is the name applied to opaqueness of the lens. Its consequence is blindness. The time was when there was no remedy for this terrible affliction, but now it is possible simply to make a little cut in the eye, next a little cut in the coat of the lens, and then, by a little squeeze, to push the lens out through the cut so made—and there lies the disordered lens in the surgeon's hand, looking almost as if made of ground glass.

To complete the cure we must supply the patient with spectacles having strong convex lenses that take the place of the lenses he has lost. Few operations, so simple, so easy, and so certain, do so much for old people; and it would be worth while to study the eye if only to learn how it is possible, by the application of our knowledge, to give sight to the blind in this way, as is done in all parts of the civilized world many times daily.

THE MARVEL OF HEARING

WE know something of the brain and the spinal cord, which together are called the central nervous system. But when we study the history of the central nervous system, we find that it has been developed from the surface of the body, and this fact in itself argues—as all the other known facts do—that its first business is to receive communications from the outside world. At the present time these communications take very definite lines, which we call the senses.

THE SENSES BY WHICH WE KNOW THE OUTER WORLD

THE senses which communicate with the outer world are those of seeing, hearing, taste, smell, and touch. These senses come from the organs inside the body, from the muscles and joints, and from certain wonderful little canals in the inner ear.

We know that there is a special part of the brain concerned with hearing. If we were to use the word ear for the part of the body that really hears, we should certainly have to say that the real ear is in this part of the brain. The ordinary ear is on both sides of the brain, and the ear for music, as we say, is probably on the left side only in right-handed people, and on the right side only in left-handed people, though in great musicians the sensitive ear for music may per-

haps be developed equally on both sides of the brain.

But we are quite certain that sound cannot be heard directly by this real ear in our brain. The brain only responds if the communication is made to it through the proper channel. So what we now have to study is the channel that leads from the outside to the hearing center in the brain. Perhaps the best use of the word ear would be to describe the whole structure, from the surface of the body to the tiny nerve cells where the hearing is actually done.

WHY ANIMALS PRICK UP THEIR EARS AT ANY SOUND

IF we begin at the surface of the body, we find in ourselves and in most of the higher animals a pair of organs projecting from the head, which are the only parts of the organs of hearing that we can see, and which we therefore call the ears, though they are by far the least important part of the whole organ of hearing, especially in ourselves. We have all observed a dog prick up its ears, and so we learn that the real use of the ear—or, as we should properly say, the outer ear—is to catch waves of sound.

It is the general rule that the outer ear is provided with small muscles by which it can be moved in various directions. This serves two

purposes. First, it enables the animal to make the most of the sound that comes to it, for the sound-waves are, to a certain extent, gathered up by the outer ear, and so are made rather more intense.

But the second great advantage of being able to move the outer ear is that it greatly helps to decide where a sound comes from. This is of great importance to such an animal as the antelope, which hears a sound and fears that it is the voice of a lion. We all have opportunities of observing how animals prick up their ears, and we can imagine them saying to themselves: "Where does that sound come from?"

We are able still to judge the direction of a sound, but we cannot do so anything like so well as the lower animals, and the reason, no doubt, is that our outer ear no longer helps us.

Yet the outer ear is not entirely useless to us. If it is all filled up except just at the opening of the canal that runs inward, we hear less clearly. This shows us that to some small extent the outer ear is still useful as a sort of ear-trumpet, though vastly inferior to that of most of the lower animals.

THE GREAT IMPORTANCE OF THE DRUM OF THE EAR

FROM the outer ear leads a little channel, along which the sound-waves pass. When we cleanse our ears, we cannot and do not wash this channel. It would be a very serious matter if we had to do so, for there would be grave risk of doing harm at its inner end. Yet, as a rule, this channel is kept perfectly clear and open, even though it is never washed. It is lined by tiny glands which produce a sort of wax, and as this wax passes outward it carries impurities away with it. We think of this wax as a rather unpleasant thing; but, in reality, it is a beautiful means of cleanliness and protection. At its inner end this canal is closed entirely by a piece of thin, delicate membrane, which is exactly like a drum-head, and it is called the drum of the ear, or tympanum. This drum is exceedingly important for the purposes of hearing, and it is a delicate thing. If it is injured, it is, as a rule, injured permanently, and the hearing is affected.

This precious drum of the ear is liable to be injured from within; and earache in children, or indeed in any one, should not be neglected, because it means, as a rule, more or less of a threat against the health of the ear-drum. We shall understand this better when we see what is on the inner side of this drum.

If we could see beyond the ear-drum, we should

find that it made one of the walls of a little space, or chamber, hollowed out inside one of the bones of the head. This space is known as the middle ear. The bone in which it and also the inner ear lie is called the petrosal bone, from the Greek word for a rock, because it is the hardest bone in the whole body. This is interesting because a hard bone must undoubtedly conduct waves of sound very much better than a softer one.

THE LITTLE TUBE THAT RUNS FROM THE THROAT TO THE EAR

THIS middle ear is filled with air, and naturally we must ask where the air comes from; the answer is that it comes from the throat. There runs from the back of the throat on each side a little tube which goes to the middle ear and conveys air to it. If we shut the mouth and hold the nose, and then make a sharp movement as if we were sneezing, we can feel something happening in our ears. This is because when we made that movement we opened the little tubes, and drove some air along them into the middle ears. It is a very important thing for the safety and health of the ear, and also for the immediate purposes of hearing, that the air-pressure on both sides of the drum of the ear should be the same.

If the air-pressure were greater on the outside than the inside of it, the drum of the ear would be driven inward and strained. If any disturbance in the throat or nose closes up these canals, so that air cannot get along them, this is liable to happen.

Every one knows that a cold in the head often causes deafness. The reason is that the cold, as we call it, spreads along the tubes that run to the ear. The lining of them becomes swelled up, and so they are closed, and cannot do their duty of keeping the air-pressure of the middle ear the same as the air-pressure outside. Hence the drum of the ear is strained and cannot vibrate as it should do to sound-waves, and so we are deaf for the time.

HOW THE HAMMER, ANVIL, AND STIRRUP CARRY SOUNDS

THE most remarkable thing that we find in the middle ear is a little chain of three tiny bones, much the smallest bones in the body, which are there for a very special purpose. They are called by Latin names that mean the hammer, the anvil, and the stirrup, and the stirrup especially is exactly like its name. The handle of the hammer lies against the drum of the ear; the hammer is

jointed to the anvil, and the anvil to the stirrup, and the foot of the stirrup lies against another sort of drum which leads to the most wonderful place of all—the inner ear.

The business of this chain of bones is to carry sound-waves across the middle ear. That is why it has to be filled with air, for otherwise they could not vibrate freely. Every time a sound-wave causes the drum of the ear to vibrate, it sets in motion the hammer-bone which is fastened to it, and so the vibration goes on. If the joints between the bones become fixed, the hearing is spoiled in some degree. This may happen in old age.

Lastly we find two muscles, very tiny but very useful, which pass into the middle ear. They have opposite uses, and we unconsciously call them into action according to whether we want to hear a sound more acutely or less acutely. One of them is so arranged that when it pulls it tightens the drum of the ear. That makes the drum vibrate more energetically, and so we hear better. Whenever we strain to hear, we throw this little muscle into action. It is called by doctors the *tensor tympani*, which simply means the stretcher of the drum.

The other muscle has just the opposite effect. It is attached to the stirrup-bone in such a way that when it pulls the bone cannot vibrate as well as usual. So when this muscle is in action it interferes with the conduction of sound to the inner ear, and when a noise is unpleasantly loud we throw this muscle into action. It is noticed that in certain cases when there is anything the matter with the nerve that supplies this muscle, loud sounds become unusually painful.

THE INNER EAR, MORE WONDERFUL THAN THE OUTER EAR

THE more closely we study the middle ear, the more wonderful we find it, and we are almost inclined to think that there can be nothing quite so exquisite and perfect in the whole body until we come to study the inner ear, compared with which the middle ear is almost clumsy. The whole purpose of the chain of bones in the middle ear is to carry the sound-waves from the drum on its outer wall to a similar sort of membrane on its inner wall, on the inside of which is the inner ear. The inner ear is filled with fluid, and every sound that we hear reaches the nerve of hearing by conduction through fluid.

We think of sound as a wave in the air, and that is what it usually is; yet in its last stage, before reaching our nerves, every sound we hear is made of waves in water.

The main part of the inner ear is a tiny and very delicate spiral bony structure, rather like a snail's shell. All this is filled with fluid. When the foot of the little stirrup-bone is thrown into vibration by a sound, it vibrates the membrane to which it is attached, and so starts a series of rapid little taps to the fluid which is lying against the inner side of that membrane, and the waves thus started run right along this spiral coil.

Now, when we carefully examine the inside of this coil with the aid of a microscope, we shall find that we have really come to the essential part of the machinery by which sounds are received. All the rest that we have studied is merely for conducting the sounds. The outer ear, the canal leading from it to the drum, the chain of bones, and the spiral canal filled with fluid, are all mere arrangements for getting the sound in the best possible way to the ends of the nerves of hearing.

THE FIBERS OF THE INNER EAR THAT ARE LIKE PIANO WIRES

BUT we have not yet actually reached the ends of the nerves of hearing. The little nerve-fibers do not hang freely in the fluid of the spiral canal, for there is something in between. We find that along the whole length of the canal, stretched across it from side to side, there is a sort of platform made of delicate fibers. Their number runs into many tens of thousands. The canal gets narrower as it reaches the top of the spiral, and so these fibers get shorter.

If the spiral were arranged flat, in a straight line—which it doubtless would be but for the fact that a spiral takes up less room in the head—we should see that the fibers are very like a series of piano wires, or like those toy musical instruments made of strips of metal that are struck with little hammers. Many people suppose that there is a meaning in the resemblance of these fibers to a musical instrument.

We know cases where people have been perfectly deaf to one or two notes of the piano, but could hear all the notes above and all the notes below; and in some of these cases it has been found that the piano in the inner ear, so to speak, has been damaged in a way corresponding with the gap in the person's hearing.

Now, upon the whole length of this series of fibers are set a number of small but wonderful cells, each of which has a few little things like short hairs sticking out from it, and these little fingers, or hairs, lie in the fluid of the spiral canal. Probably it is these tiny, hair-like fingers

that receive the waves of the fluid, and then something happens in the cells. Lastly, if we examine carefully the lower part of each of these cells, we find that the nerve of hearing, which has come to this place from the brain, has sent a few tiny fibers that end at the base of these cells. The fibers do not run into the cells, but the cells are, so to speak, set upon the ends of the little nerve-fibers.

Now we have actually traced the sound from the outer world to the ends of the nerve of hearing. We have seen the path of its conduction, sometimes along canals filled with air, sometimes along little bones, then along the canal of fluid, and, lastly, through their hairs into certain special cells made for the purpose. We might suppose that the next thing to happen would be that the sound, having got so far, runs along the nerves of hearing to the brain; but nothing of the sort occurs.

THE GREAT MARVEL OF NERVE-CURRENTS, AND THEIR WORK

THE sound which reached the hair-cells of the inner ear does not pass along the nerves of hearing, but it sets up in them a nerve-current which runs to the brain. That nerve-current is not a sound-wave; it is utterly different in every way from a sound-wave. But it is that current, and that alone, which excites the hearing cells in the brain, and enables us to say that we hear.

If we examine the nerve of hearing through a powerful microscope, it looks just like any other nerve. But to say merely that it is capable of carrying a nerve-current which we translate into sound is not to state half the mystery, for we must consider the infinite variety of sounds that we can hear and distinguish.

What must be the number and delicacy and variety of the nerve-currents passing along these nerves of hearing when a great musician conducts a big orchestra, and can hear every instru-

ment separately, and know whether it is in tune or not! How delicate must be the varieties of current that are possible when we remember that we seldom mistake the voice of one friend for that of another, even after an absence of many years.

So long as we confine ourselves to the study of the inner ear, and see the tens of thousands of fibers of different lengths, and the hundreds of thousands of hair-cells which it contains, we are not so much puzzled, because here is something which seems fitted to correspond with the powers of the sense of hearing.

There ought to be the power of noticing slight differences in sounds by means of an organ so complicated as the inner ear is. But the inner ear would not be of the least use without the nerve of hearing, and every one of these tiny differences in sounds means a tiny difference in the *something* that runs along the simple little white threads that serve to make up this nerve.

Language cannot say how wonderful these things appear to those who really think about them; the fact that nerve-currents, and not sound-currents, travel along the nerve of hearing is a general truth of all the senses. It is not light that travels along the nerve of vision. The place in the brain where we see is enveloped, and lives always, in utter darkness; no light ever reaches it. What reaches it is the nerve-currents from the nerves of vision. All that the light does in entering our eyes is to do something which starts those nerve-currents in the ends of the nerve of vision.

And all that sound does in entering our ears is to start certain nerve-currents in the ends of the nerve of hearing. When we study the variety of sensations that are possible for us, we see that a nerve-current, though we talk of it so easily, must be about the most complicated and wonderful thing in the world, compared with which the waves of sound, or light, or electricity, must be considered quite simple.

SMELL AND TASTE

SMELL and taste are two senses which are of very trifling importance compared with hearing and sight, and we certainly need waste no time in troubling to ask how they may be taken care of; but they are, nevertheless, very interesting.

These two senses are often called the chemical senses. Unlike hearing and sight, they do not depend upon waves, whether in the ether or in the air. We smell or taste only when the thing is

actually touching the parts of the body which have this power; we see and hear at a distance, so to speak, but we cannot smell or taste at a distance. When we seem to smell at a distance, particles of the thing we are smelling have been carried through the air to the nose. This fact that smell and taste are so limited in their range makes them very inferior to hearing and sight.

Only a very small part of our knowledge

of the world in which we live enters by these two gateways of knowledge—the senses of taste and smell. We know that these two senses are declining among the higher animals, and especially in mankind. While the senses of sight and hearing have become more important, the senses of taste and smell have become less so. These two senses are closely allied, and they very commonly work together. The taste of such a thing as cinnamon is very like its smell.

We do not smell with the whole of our nose. Roughly speaking, we may say that it is the upper third of it that we smell by. The rest of the nose is lined by cells which have little projections that wave backward and forward and keep the channel clear; but the smell-region of the nose is lined by special smell-cells, which correspond to the special cells of the inner ear and the retina. Each of the smell-cells is connected with a tiny nerve-fiber of its own. We find that this tiny nerve-fiber really grows out of the smell-cell, which is therefore a nerve-cell that has become changed.

THE TWO PAIRS OF NERVES IN THE NOSE, AND THEIR WORK

THE nose is supplied by two pairs of nerves coming from the brain. These two pairs of nerves are quite different in their duties. One pair has nothing at all to do with smell, but has to do with ordinary feelings in the nose. Anything tickling, or pricking, or hurting the nose affects these nerves; so does a thing like ammonia, which is irritating, besides having a smell. But this pair of nerves is not affected at all by scents that are not irritating.

The other pair of nerves that come to the nose are the nerves of smell; they are known as the first pair of nerves, because they come from the brain in front of any others. These nerves are apt to wear out, so to speak, in old age, so that old people lose, in some degree, their sense of smell, just as they often become deaf.

As every one knows, there is an endless number of possible smells. Naturally, we wish to try to group them in the same manner that we group tastes, but it really is very difficult to classify smells in any way that people would agree upon. A very large number of oils found in plants have rather the same sort of smell, though, perhaps, it is not very easy to recognize any particular resemblance between such smells as turpentine and lavender.

Still, on the whole, there is a general family likeness between the smells of plants and flow-

ers; and, when we examine the oils that cause these smells, we find that they are related to each other in their chemical build. There are certain other groups of smells, such as the group to which carbolic acid belongs; and we can learn enough to see that there is a connection between the chemistry of a compound and its smell, but that is about all we can say.

WHAT SMELL AND TASTE REALLY DEPEND UPON

It is interesting to notice that sneezing cannot be excited through the nerves of smell, though it can be excited through the nerves of ordinary feeling in the nose, and through the nerves of sight. Also, it is noticed in the case of all the senses, more or less, that they are aroused by *differences* outside them, and soon take much less notice, so to speak, of what excited them very much at first, if it remains the same. This is more striking, perhaps, in the case of smell than in that of any other sense. We have all noticed how quickly we cease to be aware of a smell which at first was perhaps very unpleasant.

The sense of taste resides mainly in the tongue, but does not depend alone on the tongue. The special cells which are concerned with it, corresponding to the special cells found in the organs of the other senses, may also be discovered on the lower surface of the soft palate, and scattered over part of the throat in front of the tonsils on each side. A person who has lost his tongue does not entirely lose his sense of taste.

As in other cases, special nerve-fibers run to the cells of taste, which are most abundant on the back part of the tongue, along the upper part of the edge of the tongue, and at its tip. Taste is much less acute on the front part of the surface of the tongue. We can notice this especially if we place a quinine powder there and then swallow it.

WHY TASTES ARE CLASSIFIED MORE EASILY THAN SMELLS

TASTES can be classified much better than smells. Most of them come under the headings of bitter, sweet, acid, alkaline, and salt. The last three of these are probably not pure tastes, but mixtures of taste and ordinary feeling, so they can become painful when they are very strong. But bitter and sweet are probably pure tastes, and, however strong, and perhaps unpleasant, they can never cause such pain as the others do.

If things are to be tasted, they must be dissolved in a liquid. We do not taste solids, and we do not taste gases, unless they are dissolved in water or some other liquid.

With great labor and difficulty, the nerve-fibers that have to do with taste have been traced from the tongue, palate, and throat to the brain. The curious thing is that there are not separate nerves of taste as there are nerves of smell, sight, and hearing; but the special nerve-fibers of taste run along in other nerves which have nothing to do with taste, and they do so in a most extraordinarily complicated way. We do not yet know what the meaning of this is, but it is evident that in the history of evolution there must have been

a very large number of shiftings and changings in the arrangements that have to do with matters of taste.

It is certain that, on the whole, both these chemical senses have great uses, far beyond merely being able to let us distinguish between one thing and another. On the whole, they indicate what is harmless or good for us, and teach us what we ought to avoid. There is no doubt about this, as regards the sense of smell. Much more important really is the case of taste, which has so much to do with what we eat and what we refuse to eat. It is probable that the sense of taste of a healthy child, rightly brought up, is the best guide as to what it should, or should not, eat.

THE HAIR AND THE NAILS

IN many parts of the body are special cells in the skin, with power of making certain outgrowths of skin which we all know very well. Our skin does not produce so many of these as does the skin of many animals, but at any rate it produces two kinds of outgrowth—hair and nails. Our nails are very interesting, for they correspond to the claws of a cat or a tiger, and also to the hoofs of a horse. A horse's hoof is really the

by means of which we are able to do things for which animals require claws and teeth. Still, our nails remain, though they are too weak and thin to be of much use. They have a very interesting history. They grow from below, and can be completely removed without destroying the cells which make them. If you play ball you may have a nail hurt. If it is badly hurt, it turns blue. That means that a blood-vessel has been injured, and there has been some bleeding under the nail. In course of time the nail gets loose, and comes off, and then a new nail gradually forms underneath it. But if damage had been done to the special cells which have the power of making the nail, then no new nail could ever form again.



HAIR ENORMOUSLY MAGNIFIED.

The picture also shows the roots of hairs embedded in the skin.

nail of the middle finger or the middle toe; it has lost the other fingers and toes, or rather its ancestors lost them.

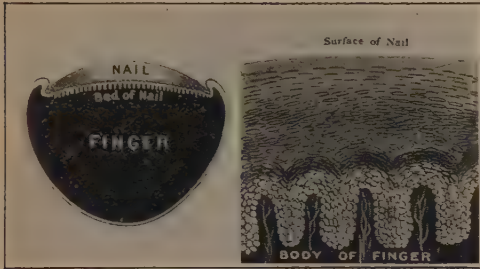
For many creatures, these outgrowths of the skin at the ends of their fingers and toes are extremely important. Perhaps they catch their prey by them, or else they walk upon them, or else they can climb by them. But in human beings these things have lost their importance, just as so many other parts of our bodies have lost their importance, because we have intelligence,

HOW OUR HEALTH AFFECTS THE GROWTH OF OUR NAILS

PERHAPS you have noticed that sometimes the nails show white lines across them, or even little grooves. After an illness, these marks may appear on all our nails, and at just about the same height in each case. They mean that during the illness the blood was not healthy, and so the cells that make the nails did not do their work properly, and therefore these little flaws appear. Gradually they pass up to the tip of the nail, as it is pushed onward, until at last they disappear. Any one who notices this could guess that it was the result of an illness. This is one of the ways by which certain people pretend that they can tell you all about yourself by looking at your hands.

Hair is the other thing which our skin pro-

duces. The part of the hair that shows above the skin is really made of very much the same kind of material as the epidermis, or outer skin, which is also very similar to the material that the nails are made of. The hair has various uses. In a



HOW OUR NAILS GROW.

The picture to the right shows the finger as if cut across down through the nail.

creature like the cat, it serves for warmth. Our own hair is so slight in quantity, except upon the head, that it has no use for this purpose. Indeed, our hair, like our nails, is mainly a sort of relic, reminding us of our relation to the whole animal kingdom.

Almost the whole of the skin is covered with fine hairs, but there are none on the palms or soles, and you will never find any one who has a single hair growing on the last joint of any of his fingers. The most useful hair that we have in our bodies is certainly that which makes our eyelashes, for that protects the eye.

THE WONDERFUL WAY IN WHICH OUR HAIR IS MADE

If we look at the fine hair on the arms, we notice that it runs in different directions in different parts. It has been noticed that these directions are the best for a creature sitting huddled up in the rain, for they would help the rain to run off the limbs. The hairs on the arms run to the elbow, and the hairs on the legs run away from the knees. But as we never sit in the wet, huddled up with no clothes on, this does not matter much to us. Still, it is interesting, just as it is interesting to remember that the valves in our veins are arranged as if we were meant to walk on our hands and feet.

Each hair grows from a special little place in the true skin. If the true skin is destroyed, a scar forms, and we may feel all right again; but nothing can ever form true skin again. A scar is not skin. There are never any hairs to be found growing from a scar, and when the rest of the body is dripping with sweat, a scar will be

perfectly dry, for it never has any sweat-glands in it. The special little places from which the hairs grow are very complicated and beautiful. Every hair really consists of six layers, all of which are made by the cells of the little hair-bulb from which the hair grows. But each hair requires to be looked after, or it will become brittle, and break off. So there are special glands—usually two to each hair—which produce a kind of oil that keeps the hair soft and pliable, and prevents it from cracking. Also, every hair has a muscle which is attached to its root, and when this tiny little muscle contracts, it pulls upon the hair and makes it stand upright. This is common in animals but not in human beings.

HOW THE CAT MAKES ITS HAIR STAND ON END

We scarcely ever use these little muscles, and no one can use them by his own will. Like the hairs themselves, they are relics from the past. A cat has them, and every one who keeps a cat has seen its hair stand on end. A possible use of this is that it may help to clean the skin. But there is a more likely explanation still. When an animal like a cat makes all its hair stand on end, the cat looks much bigger and more alarming than when its hair lies flat. It is probable that this is of use to animals in helping them to frighten their enemies.

The hair of the head varies very much in different races of men. In most of us it is fairly straight and long; but the hair of the negro is quite different. It is very short and woolly, and if it is cut across and looked at under the microscope, we see that it has a different shape. These differences of shape serve to distinguish one race of men from another race much better than do differences of hair-color.

THE TEETH ARE SIMPLY OUT- GROWTHS FROM THE SKIN

It is interesting to know that the teeth are really outgrowths of the skin, just as nails and hair are. The history of teeth begins with the fishes, and in them we can clearly see that the teeth are a special row of skin-projections that form round the edge of the mouth. In the development of each one of us the teeth are really formed from a sort of inturning of the skin that lines the mouth. All animals above the fishes have this development, with the exception of the birds. We know that the earliest birds had teeth, but no kind of bird alive to-day has teeth; they have beaks

instead. These also are really outgrowths from the skin.

In some of the lower animals the skin is a very important organ for breathing. It is so thin that the interchange of gases between the blood and the air, which goes on in our lungs, can actually go on through the surface, or almost the whole surface, of the body. This, for instance, is the case with the frog.

Though the skin is waterproof—so long as the outer skin, or epidermis, is uninjured—yet things dissolved in fat or oil can be rubbed into the skin through the openings of the sweat-glands. Various medicines can be taken in this way. Often children take cod-liver oil in this way, when it would upset their stomachs if they swallowed it.

HOW OUR BODIES BECOME SENSITIVE TO HEAT OR COLD

ANY part of the skin can be made very sensitive to cold, so that, if it is exposed to cold, the whole body may be disturbed in such a way as to make us ill. The way to do this is simply to cover the skin. The thinnest and most delicate part of the whole skin is the skin of the face, but as we do not cover that up, we do not "catch cold," as the saying goes, by exposing it. As a rule, the skin of the hands is exposed, and so we do not catch cold when our hands become cold. Now, the skin of the feet, or, at any rate, the soles of the feet, is very thick and hard—the greatest contrast in the whole body to the skin of the face. But in this part of the world people always cover their feet, and that is the way to make the skin sensitive to cold. The consequence is that if our feet get wet we very often "catch cold."

In some cities we may see poor children running about or standing in the cold and wet with bare feet; yet they come to no harm. This shows that as long as the skin is allowed to do its work for itself in a natural way we do not fall ill when the skin is chilled. It is only when we cover the skin and keep it warm—whether it wishes to be warm or not—that it loses the power of looking after itself. This is true of every part and every duty of the body. If a healthy man goes on crutches, his legs become weak. If we take medicine every night to make us sleep, we soon become unable to sleep without medicine. If we protect our skin against cold, it becomes unable to protect itself.

This is a great, simple rule to which there are no exceptions, and yet we all forget it at times, though it is the greatest of all rules for the health of the body. We have our food prepared so that

we do not need to use our teeth, and then we wonder why our teeth decay. We have elevators to take us up-stairs, and then we wonder why we get out of breath when the elevator is not running and we have to walk. It is true of every part of the body, as it is true of the body as a whole, that *effort is the law of life*. There is a fine saying of one of the greatest men who ever lived, the Italian artist Leonardo da Vinci: "Thou, O God, hast given all good things to man at the price of labor." This applies to everything, even to the people who cannot stand sun or cold or fresh air because they coddle themselves too much. They have taught their skin not to labor for itself, and have made it weak and helpless.

THE TINY STRUCTURES THAT GIVE US THE SENSE OF TOUCH

BUT there still remain some most important facts about the skin of which we have said nothing. It is one of the great organs of sense or feeling. We are likely to confuse the various kinds of sensation that our skin gives us, as if they were all varieties of the same thing, but they are not. There is, first of all, the pressure sense, or sense of touch. This is quite different from the sense of pain, or of temperature.

If we examine the true skin—and particularly if we examine it in the tips of the fingers and toes—we find special little structures in it which are there for the purpose of touch. Nerves run to them, and the ends of the nerves spread out within them. Wherever these little "touch-bodies," as they are called, are most numerous, there our sense of touch is most delicate, and that is why so many of them are found in the tips of the fingers, where it is necessary that we should feel very delicately. Many of them are also found in the skin of the lips, and they also occur in the tip of the tongue. Two points can be felt as two by the skin of a forefinger, when they are very close together, but if the distance between them is increased by twenty times, we can only feel them as one when they are applied to the skin of the back. The skin of the forehead and of the palm of the hand will feel the lightest weight, while the skin of the chin requires the weight to be twenty times as heavy before it can be felt.

THE NERVES THAT GIVE US THE FEELING OF HEAT AND COLD

THE sense of heat and cold is quite distinct from the sense of touch, and has a special set of nerves

for itself. If you take a cold thing, like the tip of a lead-pencil, and pass it over your cheek, you will find that it feels colder at some spots than at others, and the same is true of anything hot. The skin seems to be made up of a host of little spots—pressure-spots that are sensitive to pressure or touch, cold-spots that are sensitive to cold, and do not feel heat at all, and hot-spots that are sensitive to heat, and do not feel cold at all.

Finally, there is the pain sense. Different parts of the body are very differently sensitive to pain, and the skin is far more sensitive in general than the inside of the body. The pain sense has a special set of nerves of its own.

We know that a woman holds a flat-iron near her cheek to find out if it is properly heated. This she does because the face is more susceptible to heat than the hand, and so she can tell if the iron is hot enough.

HOW THE SKIN HELPS US TO KNOW WHERE OUR BODY IS

So we must think of the skin as the organ for three senses—pressure, temperature, and pain—and not as the organ merely of one sense. People often say that we have five senses, but, as a matter of fact, we have many more, and three must be put down to the credit of the skin alone. It is also probable that we are helped to know the position of our body—where our hands and feet are—by the amount of stretching of the skin in one part, or loosening of it in another part, which helps the brain to know where the different parts of the body are. So, in addition to everything else that it does, the skin contributes to our sense of position, one of the senses without which it would be very hard to live, but which few people have heard anything about.

THE MOUTH AND THE TEETH

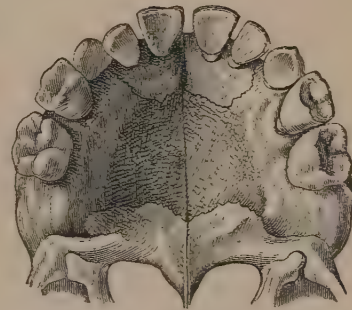
As every living thing is constantly wasting away, every living thing must feed, or its body will be consumed. This is equally true of plants and animals.

In the humblest animals, such as the ameba, the eating is done by any part of the surface of the cell—which is the whole body of the animal. But it is not long in the history of animal life before we find a permanent mouth appearing as a definite part of the structure of the animal's body. When we come still higher, to the animals that have backbones, there is never any mistaking the mouth.

The backboneed animals have heads consisting of two parts which we can always distinguish, the skull and the face. The face has openings in it for air and food—openings which we call nose and mouth; and the bony skeleton of the face always includes two strong bony arrangements which we call the jaws. The upper jaw is always fixed to the rest of the face and skull. You never move your upper jaw when you speak or when you bite. You can only move it as part of the whole head. But the lower jaw hangs from the skull, and is movable. The jaws are very strong, and the movement of the lower jaw upward is controlled by very strong and large muscles for purposes of biting.

Whether the food be grass or whether it be the body of some other animal, it must be torn and cut and crushed, and so we find that there appear in the jaws things called teeth. These appear

first in fishes, and we can prove that they really develop from an infolding of the skin round the mouth. They are really skin structures like nails. But in the course of animal development they have become fixed in the jaws. If you can get a glimpse of the open mouth of a tiger, you will see what a magnificent machine, for power and



THE MILK-TEETH.

This shows the ten teeth in the upper jaw of a child. These are the temporary, or deciduous (falling), set of teeth in human beings.

effectiveness, has been made by this combination of jaws and teeth. The jaws of a tiger cannot always be seen, but a cat is really a kind of small tiger—at any rate, a tame cousin of the tiger—and if you look at the jaws and teeth of a cat you will see the same wonderful arrangement as the tiger's, only on a rather smaller scale.

The first and oldest birds had teeth; but no

kind of bird now living has teeth. The beak of a bird corresponds to our teeth and lips.

THE MANY KINDS OF TEETH AND THE WORK THAT THEY DO

TEETH are of many different kinds; some are for catching and tearing, like the long teeth of the dog or cat; others are for spearing, like the long teeth of the elephant, which we call its tusks, and the beautiful hard outside of which we call ivory. Others are for poisoning, like the poison-teeth of snakes, which have a channel running through them for the poison which the snake makes in glands below and beside its lower jaw. And most of the animals that have teeth have special teeth for crunching and grinding. These are usually behind, of course, while the sharp teeth, that catch or bite, or spear or poison, are in front, where they will be most useful.

The teeth of different kinds of animals are a very good guide, even if we have nothing else to go by, to the habits of the animal to which the jaws belong. You would not expect a cow to have the same kind of teeth as a tiger. The study of the teeth of animals is of great value in understanding how animals are arranged in classes, and also how different kinds of animals are related to each other. All human beings have the same number of teeth—to begin with—and the teeth are of exactly the same kind, and the same number of each kind.

HOW TEETH SHOW US THAT ALL KINDS OF MEN ARE ONE

THE oldest human skulls we can find anywhere—some of them several thousand years old—show the same arrangement of teeth as all human beings now exhibit. This exact arrangement is different—though not very different—from that found in any other kinds of living creatures except the highest monkeys or apes. The kinds of apes which are most nearly related to man have the same arrangement of teeth as he has. In the lower monkeys the arrangement is slightly different.

As every one knows, we have two sets of teeth. In the first set we have twenty, and in the second set thirty-two. The first teeth of the first set begin to appear about the sixth or seventh month after we are born. The first teeth of the second set begin to appear at about the age of six; and the last four of the thirty-two do not show above the gums until we are nearly grown up, which is

when we are supposed to be wise, so they are called "wisdom" teeth. The number of teeth in each jaw, and on each side of each jaw, is the same. The flat front teeth are called incisors, or cutters; the corner teeth, canines, because these are the teeth so big in dogs; and we may call all the rest molars. The last molar on each side of



ADULT TEETH.

Children shed their first twenty teeth to give room to a permanent set of thirty-two. The illustration shows eight of these.

the two jaws is a wisdom tooth. There is no doubt that the teeth and jaws of human beings are growing smaller and weaker. In many persons the wisdom teeth never appear at all.

THE HISTORY OF OUR TWO SETS OF TEETH AND THEIR NAMES

OF course, the reason is that teeth are getting less and less important as man gives up, one after another, his primitive way of doing things. Now we can choose and cook our food, and though good teeth are always a blessing, yet people may live happy and useful lives even though they have lost all their teeth.

The teeth of the upper and lower jaws are not set exactly opposite each other. Thus, if a tooth is lost, the tooth that corresponds to it in the other jaw is not made useless for the rest of the person's life. It still meets part of a tooth next to the one that has been lost. This peculiarity in the arrangement is a most valuable one. But for it, to lose one tooth would really mean losing two.

When our teeth are formed they do not grow any more. If they are properly used they remain healthy. This principle is true of every part of

every living thing, and it is important that we should understand how to keep our teeth in good condition.

In some animals the teeth grow and grow, but wear each other away, so that they do not get too long. If the tooth of such an animal is lost by accident, the tooth opposite will go on growing, with nothing to wear it away, and may force the mouth of the animal open until it cannot eat, and it dies of starvation.

Animals that live on other animals always have long, sharp teeth. These animals are called carnivorous, or flesh-eating. Animals that live on grass, and similar food, are called herbivorous, or herb-eating. They often have no tearing teeth at all, but merely crunching, grinding teeth. An animal like a rabbit, which is a rodent, or "gnawer," has gnawing teeth.

THE FOOD THAT MAN IS INTENDED TO EAT

It is a very interesting question to decide, by studying his teeth, the kind of food that man is really meant to eat; and we are helped by studying the apes. We find that apes live on fruits and the like, not on the flesh of other animals; and their teeth, which are practically the same in every respect as ours, are not suited for killing and tearing. Our own teeth do not belong to the carnivorous type.

If all our teeth are perfectly sound, or properly filled by the dentist when they have decayed, sweet things will not make them ache. All sound teeth are completely covered, in all the part that shows above the gum, by a layer of what we call enamel. This enamel has no nerves in it, and therefore cannot feel. The case is quite different, however, when any part of the enamel of the tooth has been slowly melted away by the acids which microbes produce in our mouths. The part of the tooth underneath the enamel is called the dentin. It is much softer than the enamel, so that things can pierce some little distance into it, and it is filled with tiny branches of the nerve that goes to each tooth. These nerve-ends are not disturbed by most of the things we eat, but sugar is one of the things that excite them, and so, if any of our teeth have their dentin exposed, we are liable to get toothache.

Very often it may be only one tooth that has its dentin exposed, yet the whole of that side of the jaw, or nearly the whole of it, may ache. The reason is that all the nerves going to the teeth along one side of either jaw are branches of one nerve, and when any part of it is dis-

turbed, all the teeth to which its branches are distributed are likely to become the seat of pain.

WHY THE TEETH OF ANIMALS OUTLAST THOSE OF MAN

We know that only very rarely indeed do the teeth of animals decay, and we know also that among savages the teeth decay no oftener than they do among animals. But our teeth are very different, and there must be something in our way of life which explains the condition. In the first place, the teeth of many of us are not perfect to begin with; the enamel is thin and soft and not smooth enough, so that it cannot resist damage so well as it should. The reason probably is that many of us are not rightly fed when we are babies. Babies and children that get plenty of fresh milk—and a little cream too—have better teeth than other people when they grow up. And another cause of the decay of our teeth is the kind of food that we eat after they are formed. Animals and savages eat very hard and fibrous food, while some of us actually cut off the crust of toast. If we give our teeth no work to do, they are bound to become weak, for it is a universal law of all life that anything which is not used, or has its work done for it, gets weak and helpless.

We should take care of our teeth by giving them work to do. We should not be afraid to use our teeth on food instead of cutting it up too much with knives.

THE GREAT IMPORTANCE OF KEEPING TEETH CLEAN

THEN we must be sure, every day of our lives, and especially at night, to keep our mouths clean. If we do not do this, microbes will grow in our mouths and will form acids, especially that called lactic acid, such as is found in sour milk, which is able slowly to dissolve the chalk in the enamel of our teeth. Our saliva fortunately interferes with this acid by using it up, since saliva contains what is called an alkali; and an alkali, when it meets an acid, combines with it. It is better that the acid should combine with the alkali of the saliva than with the alkaline chalk of the teeth. So we should keep our mouths and teeth clean by using a tooth-powder which is itself alkaline, and also antiseptic, or poisonous to microbes. We should use this powder night and morning. We should not use too hard a tooth-brush, which may wear away the teeth or make the gums bleed, and we should move the tooth-brush up and down, so

as to clear the spaces between the teeth, and not merely from side to side.

A powder is always better to use for the teeth than a liquid, provided that it is a perfectly soft powder, without any grit that would scratch the tooth-enamel. A powder is best because it helps, by mere rubbing, to keep the teeth free from the coating called tartar, which is apt to cling to them. The best powder is a half-and-half mixture of carbolio powder and magnesia, and this may be bought by the pound. It is very cheap indeed. It is quite soft, it is very antiseptic, it is strongly alkaline, and it is very pleasant to use. None of the things which are advertised for the teeth are nearly so good, and the cheapest of them is ten times as dear.

WHY SUGAR IS NOT BAD FOR CHILDREN WITH GOOD TEETH

It is very important to know whether, in order to preserve our teeth, we should avoid sugar, for all children like sugar and candy, and if these things are good for them, yet bad for their teeth, we shall hardly know what we ought to do. It is true that the lactic acid made by microbes in our mouths, which is apt to dissolve the tooth-enamel, is made from sugar. One molecule of sugar is split up by microbes into two molecules of lactic acid.

But if we are careful about the cleanliness of our mouths, which is even more important than the cleanliness of the skin, we need not fear that our teeth will suffer, for the microbes that produce this change in sugar can only thrive in a mouth not kept clean.

People used to think, not very many years ago, that sugar was not good for children. A great English philosopher, Herbert Spencer, was the first to argue that this opinion must be wrong. It may be that people regarded a child's liking for candy and sugar as mere greed; and perhaps they felt the more sure of this because a child that has been deprived of sugar is sure to eat too many sweets. But every child naturally likes sugar. Perhaps Nature is not so foolish as we think in implanting this liking in children; perhaps it is we who are foolish in thinking Nature foolish.

THE CHILD'S APPETITE FOR SWEETS MAY BE A GOOD SIGN

We know now that sugar is one of the most valuable of all foods. All the starch that children or grown-up people consume is turned into sugar, before it enters the blood, and more than half the total energy of the body is derived from the burning of sugar. Now, children need a great deal of energy supplied to them in their food, because they are very active, and because, being very small, they need to produce a lot of heat to keep them warm, as their small bodies very easily and quickly lose their heat. Therefore all children need a great deal of sugar, and a child's appetite for sweets and sugar is not due to a mistake made by Nature, nor a sign of greed in the child, but the proper sign and demand for what the child specially needs. People who believe this find that children who get what sugar they ask for do not take too much, but stop when they have had enough.

QUEER FUEL

BY CRITTENDEN MARRIOTT

How many people, I wonder, ever pause to consider that their bodies are merely machines to do work, furnaces in which necessary fuel is burned, workshops in which worn-out parts are supplied, and storerooms in which fuel and food are laid away for use when needed. Further, like any other piece of apparatus, the body works better under certain circumstances: its fires burn better with fuels of certain sorts, mixed in certain proportions, and it cannot keep in perfect condition unless furnished with proper materials.

Man thinks he eats because he is hungry; he really eats because his body is crying out for

building materials with which to repair the waste that is always going on, and for fuel to keep itself warm—and it is rather "finicky" as to the supply it wants for each of these purposes. At a pinch, it can use almost anything digestible for either, but it groans and complains and punishes its unfortunate possessor if it is not properly treated.

What the body considers proper treatment is not always that which the palate or the sense of taste considers such. In fact, the palate is the spoiled child of the house; he is always demanding things that are not good for him, and, like other spoiled children, the more he is indulged,

the more he demands. Sometimes he can make things very unpleasant, for he may refuse to permit any food to pass the portal where he stands on guard, and hence may bring the whole machinery to a standstill. As a rule, however, if treated firmly, he will give in and work for the good of all.

"Savory" food pleases the palate and causes a greater flow of the various juices and ferments and so promotes digestion. It is therefore a good thing within proper limits, but what the body really needs is protein and heat.

"Protein" is a word with which few of us are familiar; we are familiar enough with the thing, however, and it is really impossible to talk about these matters without using one or two scientific words. The lean of meat, the white of eggs, the gluten of wheat, are all mostly protein, and we all know how necessary a supply of one or more of these, or of similar things, is to us, if we do not wish to suffer from hunger or from need of nourishment.

While protein can be used for heating, if necessary, its natural use is for repairing purposes, and for this end the body needs one-fourth of a pound a day. Different amounts are required for old and for young, for men and for women, for those living in cold and for those living in hot climates, for laborers and for clerks, but $\frac{1}{4}$ pound is the right amount for a full-grown man living in a temperate climate and doing moderately active work.

So much for repairing; now for heat. The body, one will say, needs a definite amount of this too. Scientific men have ascertained through countless experiments, the amount necessary for the average man and have found that it is equal to 3050 calories of heat. (Dear me, there goes another unusual word!) A "calorie" is the amount of heat that will raise the temperature of about one pound of water four degrees Fahrenheit. Sugar, starch, and fats are ideal fuels, though protein will burn well, if necessary. Nothing, however, will take the place of protein as a rebuilding material.

What the body needs, then, is a daily supply of one-fourth of a pound of protein and enough sugar, starch, and fat to supply it with 3050 calories of heat. This is an average for the year, of course. In our climate, the ration, especially the fuel ration, should be varied with the seasons.

True, certain other elements also are needed by the body, but they are required in very minute quantities, and are so widely distributed in nature that their supply is always assured. On the other hand, any food which supplies protein and fuel in different proportions than these is not

perfect; if it supplies too much heat to the right amount of protein, it is wasteful, if nothing worse; if it supplies too much protein to too little heat, it compels the body to use some of the protein for fuel, which throws an undue strain on the digestion and will probably result in disease sooner or later.

As most of us know, the price of food has little relation to its value to our bodies, however much it may have to our taste. The larger part of the price of the costlier foods is due to their fine appearance, or their pleasant flavor, or their rarity. Tenderloin of beef is less nutritious than shoulder, but it costs more, as you will find out if you go to buy it; and so with many other articles.

Then, again, some foods are more digestible than others, as we have all proved again and again, generally when we have eaten something particularly nice. We live, of course, not on what we eat but on what we digest.

During recent years, scientific men have been hard at work finding out the facts in regard to all the commoner articles of food; and these facts have been set forth in huge tables of figures that it makes one's head ache merely to look at. They contain some interesting facts, however, if one has the patience to dig them out.

Ordinary white bread, for instance, is about one-third water, one-twelfth protein, and one-half other digestible matters. If all were used as fuel, a pound of bread would supply 1200 calories; two and a half pounds per day will supply 3000 calories, about the amount required. If the protein in the bread be used for its usual purpose of rebuilding, leaving the other digestible substances for fuel, three pounds of bread would furnish just a trifle more of good fuel and protein than is required in a temperate climate by a man doing moderately active muscular work. Bread alone, then, is theoretically very nearly a perfect or "balanced" diet—though three loaves a day would certainly stir that bad boy, the palate, to rebellion.

If a man lived on bread alone he would eat, in a lifetime of seventy years, about 75,000 pounds; or, say, he would devour a loaf 30 feet high by 10 feet square, which would cost him about \$4000.

But living wholly on lean meat would be a good deal worse than living wholly on bread. To do this, a man would have to eat three and one-half pounds a day to supply himself with needed food, and would not thrive then as he would on bread. One and a half pounds of meat would supply him all the protein needed, but would yield, in addition, only about one thousand calories of heat. To make up the balance, two pounds more of meat must be eaten, all of it for fuel. Meat is a

very poor fuel, and to burn two pounds of it a day would throw a heavy strain on the digestion and probably lead to disease. Fancy eating three and a half pounds of meat a day!

Living on lean meat alone, a man would eat, in seventy years, an ox about thirty-five feet long, fifteen feet high and twelve feet thick, supposing it to consist of solid meat without bone. This would weigh about 90,000 pounds and cost about \$15,000.

Thus, bread alone worries the palate and is in time refused; meat alone furnishes too much protein and not enough heat; candy, pastry, and the like supply too much heat, which must be laid away in fat in the body's storehouse or be worked off in nervous energy. No one of the three is good without the others.

On the other hand, a mixed diet makes things a great deal better all around. One pound of bread, one and one-third pounds of lean meat, and one-sixth of a pound of butter daily would supply almost the exact ideal proportions. In seventy years, this would run to 25,000 pounds of bread, 33,000 pounds of meat and 4000 pounds of butter—62,000 pounds in all, costing, say, \$9,000.

If a man lived wholly on fish, he would require eleven pounds a day, or 275,000 pounds in a lifetime—say, a fish 70 feet long by 30 feet deep by 10 feet thick. If he lived on rice alone, he would have to eat three pounds a day, or 75,000 pounds in a lifetime—an amount which would furnish

him with about 50 per cent. more heat than he had any use for. By combining fish and rice, however, as the Chinese do, in the proportion of one pound of the former and two of the latter, he could live very well. The relative cost in this country would be about \$30,000 for fish alone, and \$6000 for rice alone. The two combined would, of course, cost much less than the fish alone.

His hardest time, however, would be when he tried to live on green vegetables or fruits alone, avoiding bread and beans, both of which play such a part in vegetarian bills of fare. Of ordinary vegetables, such as beets, cabbages, tomatoes, and the like, he would have to eat 20 pounds daily. Of fruits, he would have to eat 30 pounds daily, and even of potatoes, 15 pounds.

On the other hand, two pounds of rye bread, two pounds of potatoes, and a taste of fat, either animal or vegetable, make a very cheap, well-balanced ration, costing only about \$1500 in a lifetime. Thousands of Russian peasants live on just such a diet.

As I said before, all these estimates are for a man doing moderately active muscular work in a temperate climate. A man doing hard muscular work requires about one-fifth more, and a man in an office about one-fifth less. Boys require only one-half as much at six years of age and nine-tenths as much at sixteen. Women generally require one-fifth less than men of equal activity.



GREAT MECHANICAL MARVELS

PART II



AN ARTESIAN WELL OF WARM WATER IN WHICH CHICKENS ARE HATCHED.

NATURE'S INCUBATOR

On a ranch in a valley of the Colorado desert we find a new and strange method of hatching chickens.

Many artesian wells are in this valley to furnish water for irrigation. They are made by drilling a hole in the earth, and as the dirt is

came up with a temperature of one hundred and two degrees. Since chicks will hatch when eggs are kept just about as warm as this for twenty-one days, the people who own this well decided to use its heat to hatch eggs.

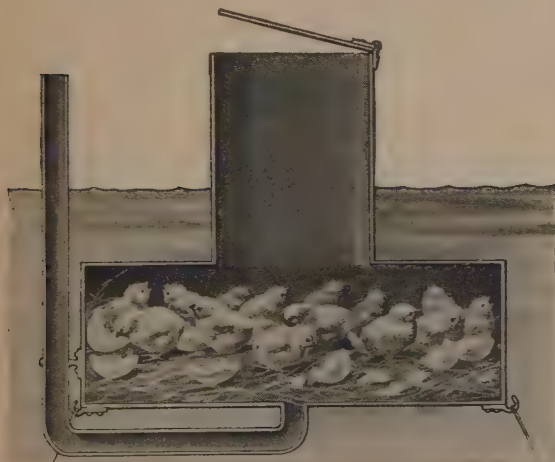
The earth was dug away from the pipe, so that the water, as it flowed over, formed a pool, in which an ingenious form of incubator can be submerged.

Of course the eggs would spoil if placed directly in the water, so a round can of galvanized iron was made, eighteen inches in diameter and six inches deep, with a chimney as shown in the figure. By stretching the arm and hand down this chimney, the eggs are placed on straw on the bottom of the can. In this way, too, they are turned twice each day, and out of the chimney the chicks are drawn when two days old. They are then placed in brooders and given their first food and water.

The can is securely fastened in the warm pool by weights. The only things that appear above the water are the chimney and the end of a small tube which is inserted in the bottom of the can and curves upward.

Through the chimney the foul air rises and escapes. Into the tube rushes fresh air with moisture which ascends as vapor from the water. Both are necessary to give health and strength to the little birds growing in the shells.

These chicks are as strong as any chicks have ever been, and, hatched in this way, it is claimed that they are out of their shells one day earlier than when a hen sits on the eggs.



THE RECENTLY HATCHED CHICKENS WITHIN THE ROUND CAN OF GALVANIZED IRON.

drawn out, a pipe is pushed in till water is reached, which then rises to the top and flows over the edge.

One hole was drilled for seven hundred and fifty feet into the earth, and a flow of water

HOW A MACHINE BEGAN TO TALK

MR. EDISON is one of the greatest inventors in the world. It was he who made a machine talk. He was working with his men one day trying to improve the telegraph. Across a little wooden frame they stretched a thin material like elastic, and in experimenting with this Mr. Edison found that the sound-waves produced by his voice greatly agitated the cover. And then Mr. Edison became a child again. He cut up some little paper figures of men and women, and the trembling of the elastic cover caused by Mr. Edison's voice made the little men and women dance. That dancing of the paper dolls made Mr. Edison think. He had found a new power, and one day he made such wonderful use of this power that, as we read this paragraph, we can sit in our own homes and hear Signor Caruso's voice come out of a box.

In the days when we were inventing the phonograph (says Mr. Edison) my assistants were working by the piece, and it was my custom, when I sketched out a design for a model, to mark on the sketch the price I was willing to pay for making the model. So I sketched out my idea of a talking-machine, marked "fifteen dollars" on it, and gave it to a man.

"What's this for?" he asked.

"Oh, that's a machine to talk," I replied. Word that I was working on a talking-machine went quickly round the laboratory, and soon the place was buzzing with it. The following day the man brought me the finished model, and pretty nearly everybody in the laboratory came with him to deliver it. It's wonderful how workingmen become interested in inventions. When I finished the electric light, I discharged fifteen laborers—had no further use for them—but they would n't quit; stayed right along, just the same.

So, when they all gathered around me, I said

to the man who made the model: "Bill, get me a little tin-foil now, and we'll make this thing talk."

I wrapped the foil around the cylinder, placed the needle of the diaphragm against it, and shouted into the funnel what were to be the first words ever spoken by a machine:

"Mary had a little lamb,
Its fleece was white as snow,
And everywhere that Mary went,
The lamb was sure to go."

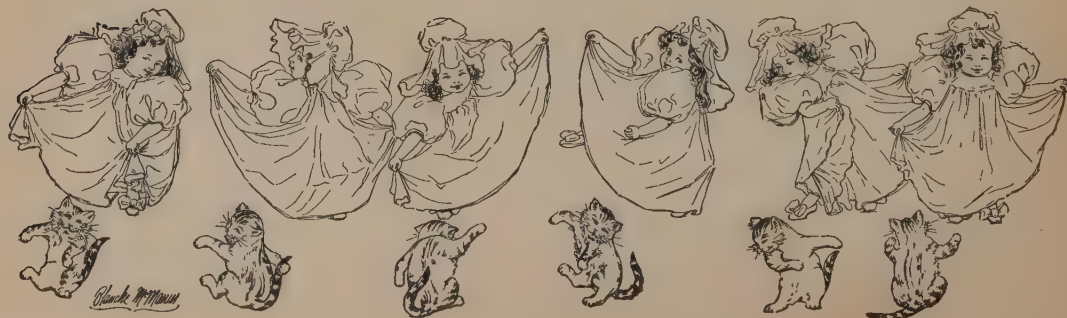
This done, I set the needle back where it started, turned the cylinder with a crank, and the machine repeated what I had said so plainly that everybody could hear it. I never saw such an amazed crowd.

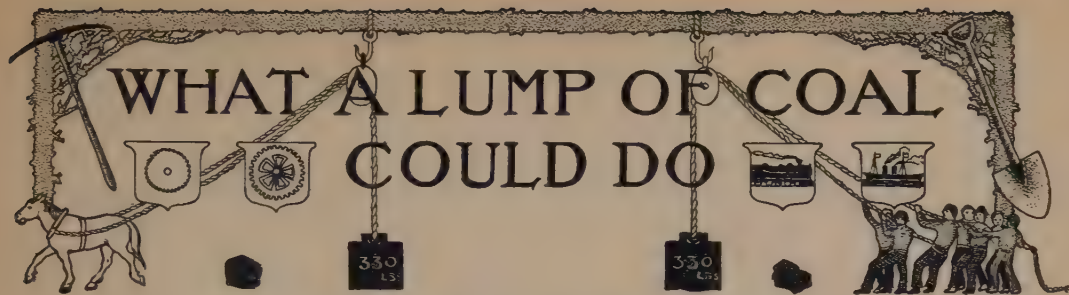
Of course, I wanted to have the phonograph patented, so I went along with it to Washington. News of the invention had preceded me, and I was besieged. Mr. Blaine asked me to go in the evening to the home of his niece, and show the machine to her family and a number of guests. I shouted into the funnel:

"There was a little girl,
And she had a little curl
Right in the middle of her forehead.
When she was good
She was very, very good,
And when she was bad she was horrid."

There was a man there with a curl, and believing that I had sought to ridicule and humiliate him by my little nursery rhyme, he was tremendously insulted and left the room.

Some of them could n't believe that it was the machine that talked. I let them make records themselves, and hear their own voices. That convinced them; but they could n't understand it. There still seemed to be something uncanny about it. Again and again I was compelled to make the machine talk. It was after two o'clock in the morning when I went home.





BY GEORGE ETHELBERT WALSH

A CENTURY ago most of the labor of the world was performed by the hard work of man and beast, and both, toiling day after day in the fields, could just about keep sufficient food ahead to prevent famines and general starvation; but to-day machinery performs most of the world's work.

Originally man-power did the world's work; then horse-power was employed; and now machinery, driven by steam, directly or by converting its energy into electricity, compressed air, or other sources of power, is doing the greater part of the hard work of man and beast.

What is the relative amount of work that a man can do in comparison with a horse or machinery? At his very best the strongest man stands in pretty poor comparison, even with a horse, for hard, continuous labor. He might perform for a few minutes one half horse-power of work, but to keep this up for any great length of time would be impossible.

Thus the gain in forcing horses to do a part of the world's work was enormous. One horse could exhaust a dozen men in a single day, and still be ready for the next day's work.

The measurement of a horse's power for work was first ascertained by Watt, the father of the modern steam-engine, and he expressed this in terms that hold to-day. He experimented with a great number of heavy brewery-horses to satisfy himself that his unit of measurement for work was correct. After many trials he ascertained that the average brewery-horse was doing work equal to that required to raise 330 pounds of weight 100 feet high in one minute, or 33,000 pounds 1 foot in one minute. So he called this one horse-power.

This work, however, is not continuous, for the horse would have to back up after each pull to lower the line of the pulley, and thus he would work four hours a day in pulling 330 pounds in the air at the rate of 100 feet a minute, and four hours in slacking up the rope. Consequently no

horse can actually perform continuously what is generally called one horse-power. The horse was never born that could tug at a rope for eight hours a day, pulling 330 pounds 100 feet each minute without rest or change. Consequently, when we speak of horse-power we refer only to the average work a horse can do in one minute, that is to say, the *rate* at which he can work.

A strong man might pull half that weight 100 feet in the air in two minutes, but he could not repeat the operation many times without being exhausted.

For all needful purposes the expression of one horse-power is accurate enough, and practically shows the measurement of an average horse's abilities for working. As a rule, a strong man can in eight hours work at the rate of about one tenth of one horse-power; that is, it would require ten men to pull 330 pounds 100 feet in the air in a minute, and then slack up and repeat the operation throughout the eight hours of a working day. The world's gain in labor when horses were first employed to help man in his work was thus tenfold.

The discovery of the application of steam marked the next change in the development of power. In order to find out how much gain was made in harnessing steam, it was necessary to use horse-power as the unit of measurement. So to-day we find steam and electric engines spoken of as, for instance, five, ten, or a hundred horse-power. Thus a ten-horse-power machine is one capable of lifting ten times 330 pounds 100 feet in the air in a minute, or 330 pounds 1000 feet in $\frac{1}{10}$ of a minute, or 330 pounds 1000 feet in a minute, and so on.

For most people it is not easy to understand how a lump of coal can furnish work; but to the scientist this is very simple. In order that this may be clear we must examine the coal and its possibilities.

Heat is a form of energy which can be harnessed to do our bidding. If you burn a lump of

coal it forms heat, which may escape into the air and be of no service to us. This was the case for hundreds of years, and the vast amount of energy that was wasted before man discovered the value of heat for purposes other than warming and cooking would have sufficed to do all the necessary work for the tribes and peoples who used fire from the time of the early Britons down to the present century.

But burn this lump of coal in close contact with a vessel containing water. The heat produced, which is measured in what are called heat-units, will make the water boil and bubble and then produce steam. This latter will likewise escape in the air and be wasted if not confined and its energy utilized as pressure or heat.

In order to express in specific terms the energy of coal, or its ability to do work, it was necessary to find some unit of measurement. Each pound of ordinary coal is supposed to give forth 12,000 heat-units when burned. The way a chemist would determine how much energy there is in a piece of coal would first be to pulverize it and then weigh very carefully a small quantity of the powdered coal and by chemical means burn it under a known quantity of water. Both the weight and temperature of the water are ascertained before and after the burning. In this way he can figure out how much heat was added to the water by the coal, and knowing that, he can express in heat-units the amount of heat given out by the powdered coal. It is then a simple matter to find out the proportionate amount of heat given out by the whole lump.

A lump of coal weighing a pound is nearly as large as a man's fist. What is the potential (or stored) energy contained in that small lump? If we could burn this pound so that not a particle of heat was lost, but all went to heat a tub of water a foot deep, six feet long, and two feet wide, it would raise the temperature 16 degrees. In other words, it would raise the water from 64 degrees to 80 degrees, making it just comfortable to bathe in. There is nothing marvelous in such an operation, and one may not think there is so great energy in coal, after all; but when we come to express in other ways the value of this heat imparted to the water quite a different story is revealed.

The 12,000 heat-units in the pound of coal that just brings the temperature of the water up so that it is comfortable for bathing purposes is equal, in a mechanical sense, to 9,306,000 foot-pounds or an amount of work equivalent to raising nearly 47 tons 100 feet high. Here is a most astonishing thing—a secret which the coal withheld from man for many centuries. While man

and beast were laboring to do the world's work, there were hidden in the earth millions of pounds of coal, each one of which was capable of doing the work that would be done by 282 horses in one minute. Or if we would express it in a *day's* work, each pound of coal could do the *full day's* work of a powerful horse, working continuously, in pulling up 330 pounds 117.5 feet in the air every other minute throughout the day of eight hours.

There are few things more remarkable than the possibilities contained in each lump of coal. A laboring man could carry in his pocket enough potential energy to perform all his tasks for several days. If this same lump of coal could be suddenly converted into heat, and that heat all imparted to water to make steam, we would be able to perform wonders. For instance, the energy thus utilized would be sufficient to run an electric-motor car full of passengers two and a half miles at the rate of twenty miles an hour. It would also carry a train of six ordinary cars and a heavy Pullman sleeper and dining-car one sixth of a mile at the rate of twenty-five miles an hour.

Coal, which the world neglected for so many ages, using it occasionally for heating or cooking, is thus one of the most remarkable of all the world's precious products—more wonderful, and in a measure more valuable, than all the diamonds, rubies, and sapphires that have ever been mined. It contains stored-up energy that has revolutionized the world; it becomes the secret of man's modern progress—the actual power which has made the last century the greatest the world has ever known. Yet, without much thought of all this, we carelessly throw scuttles of the black diamonds into our stoves merely to warm our homes with it. And we little think of the waste energy that goes up the chimney as the coal crackles and sparkles. The greater percentage of the heat is lost, while a very small portion of it is distributed around the room to warm us. But even this small part of the heat which we use for warming our rooms is sufficient to produce magic-like transformations in the world of mechanics and machinery. The heat used for cooking our dinner and for boiling the water to make coffee or tea could be made to run mills and factories if it were all saved and properly used.

Now let us compare this new power which man has found in coal with that which the human muscles exerted in the days when the great pyramids were built—when hundreds of thousands of men toiled and slaved for years to create monumental works that could to-day be built by ma-

chinery in a few years with a few thousand men at most. The power of a man for work, we will say, is only one tenth of that of a horse; but the horse compares even more unfavorably with steam and machinery, while man himself becomes a unit of such small measurement that his efforts are puny indeed.

Suppose we select a hard-working laboring man as an example—one whom we call strong and muscular, with body trained to daily toil, so that he could easily perform manual labor that would completely exhaust another not in training. Such a strong laborer is one who represents



the highest achievements of muscular manhood. He can wield an ax all day long in the woods; he can swing the shovel eight hours a day, filling furnaces with coal or digging ditches; or he can plow and harrow with firm hand and till the soil for crops. Such a man has from the beginning of the world been a mighty power in transforming the face of nature; but here comes along a pound of coal which has been buried for ages in the earth and for centuries after its discovery was esteemed as of little practical value, while if properly used the energy stored in it could perform in one minute all the work that *five* strong men could accomplish in one day, working eight hours with scarcely a moment for rest. We may put it in another way. If it was necessary to perform the work in one minute, it would take about 2800 men to accomplish the task that the small lump of coal would perform in the same short space of time.

If we let horses do the work instead of men we find still that the lump of coal is immeasurably greater in its possibilities. The single strong horse is capable of raising the 330 pounds 100 feet in one minute, or, as commonly expressed, the animal does 33,000 foot-pounds of work in a minute. The pound-lump of coal contains 12,000 heat-units, which, as we have seen, is equivalent to 282 horse-power, or 282 times 33,000 foot-pounds of work in a minute, or 9,306,000 foot-pounds of work. It would take a string of 282 horses, stretching out about half a mile long, to produce the same amount of power or work. They would just be accomplishing what a pound-lump of coal

could do if all its potential energy could be transformed into heat and harnessed for work.

Take another example of what a pound of coal can do in the way of work compared with the feeble effort put forth by man. In olden times when the saw was invented a great stride was made in mechanics. The continuous row of sharp teeth would do many times as much work as a single sharp edge; and a man armed with a sharp saw could greatly multiply his labors. But when the *circular* saw was invented a much greater device for reducing the labor of man was discovered. The circular saw can travel far faster than the hand-saw, even when driven by simple hand or foot power; but when operated by machinery the teeth will travel more than seventy times as far through the wood as those of the hand-saw in the same space of time. In other words, the steam-operated circular saw will cut something like seventy times as much wood in a minute as a strong man who works sixty strokes a minute, or one a second. That gain seems so tremendous that one hesitates to expect more; but here is our little pound-lump of coal, which can supply power enough to operate 180 of these circular saws for a full minute, performing in that short space of time all the work that 12,600 men could accomplish with the old hand-saws, moving up and down at the rate of 60 strokes a minute.

In these interesting illustrations of the power of a pound of coal, it must be remembered that the *full amount* of *potential* energy contained in the fuel is considered, and not what is only actually utilized in generating steam. The fact is that we have not yet been able to utilize more than a small percentage of the heat of coal. In its combustion a large percentage of it is wasted up the chimney, and consequently it cannot per-



form these marvels to-day under present conditions of burning. There is consequently far more coal required to do the world's work to-day than may be the case a hundred years from now, when some inventor may find new forms of grates and furnaces for burning coal so that there will be little or no waste of heat-energy, or, in other words, of power.

Coal has become man's chief worker, and horse labor and human manual labor are slowly being pushed aside. In the great transformation it has been brain power that has triumphed over brute strength. Man first sought to shift his burden to the backs of the beasts of the field, and the horse became his patient friend and assistant; but now he seeks to harness the elemental forces of nature to do his bidding. The burden is thus lightened without cruelty to any living creature; neither man nor beast has had his labors increased, but steadily decreased.

The harnessing of the waves and wind for generating electric power, or the focusing of the

sun's rays on a boiler to utilize solar heat, are but further illustrations of man's efforts to cast his burden of hard labor upon forces which are all around us, if we but knew how to release and employ them. When some of the potential power of a pound of coal was first released and harnessed to operate machinery a vital step in the progress of humanity and civilization was taken; but the time may come when even the magic power of the coal will be second in importance and practical value to that of electricity, whose strange power we are only able faintly to comprehend to-day, and whose power in the future can only be surmised.



HOW DID MEN FIND THAT THERE IS COAL IN THE EARTH?

THE coal-measures, as they are often called, form a layer in the earth's crust which is old and has had many other layers heaped up over it since the giant ferns that gave us our coal were alive; therefore we do not expect to find coal at or near the surface. But various things happen to and in the earth's crust which sometimes have curious results.

Wind and rain, the action of the sea and other causes, not yet well understood, may rub down and wash away the surface layers in places, and then what is beneath, such as coal, may be revealed. Or sometimes there may be greater and perhaps much more sudden happenings in the earth's crust, due to the action of the heat that is imprisoned beneath it, or to the breakage of a layer owing to the increased weight of the layers above it, or due to the production of heat by means of radium and the other elements which belong to the same group.

In this way there were possibly found certain curious and easily broken black stones which, unlike all other stones, would burn. This may have happened when men were quarrying or cutting a little distance down into the earth for some other purpose. Afterward, it was found how the coal lay and in what parts of the earth it is most readily obtained.

WHAT IS THE USE OF COAL-TAR?

BESIDES gas and ashes, we can get out of coal the stuff we call tar or coal-tar, and this has all sorts of remarkable uses. It is one of the most complicated things in the world, outside the realm of living things, and it is so, just because it is really the product of living things of long ago. Nothing could be uglier or less interesting to look at, yet it is the source of some of the most exquisite colors in the world. All sorts of beautiful dyes, used for clothes and many other things, such as painting, are made from coal-tar. The great discovery of the first of these, called mauve, and of many more, was made by an Englishman named Perkin, who died a short time ago. But science has never been properly treated or understood in England, and so now we get nearly all our coal-tar dyes from Germany, where Perkin's work was properly appreciated.

But we get still more useful things from coal-tar, for it contains substances which can be made into all sorts of medicines, and especially such things as carbolic acid, which kills microbes, and has already saved millions of human lives since its use was discovered by Lord Lister just forty years ago. Indeed, it would be quite easy to write a book about coal-tar, which is now known as one of the most valuable things in the world, though only half a century ago it was looked upon as little more than mere worthless waste.

RUNNING A RAILROAD BY ELECTRICITY

MANY persons, young and old, often wonder how the modern electric cars, trains, and locomotives are operated, and what electricity is. No one knows what electricity is. We know some of the things that it will do; we have, to a certain extent, learned how to control it, and, for want of a better name, we call it a fluid. We have discovered, too, that it is one of the most important forces, if not *the* most important force, of which



we have any knowledge. We are almost as ignorant of many other great forces of nature, as, for example, the attraction of gravitation. For the present we must be content to observe such forces in action, and to devise the best methods to control them. In this knowledge mankind has progressed wonderfully within a few years. In the cities and in many towns the application of electricity to trolley-cars is a familiar sight. In the smaller places these cars are operated by electric power that comes from an overhead wire, and in large cities from an underground conductor. Within a few years, the New York, New Haven & Hartford Railroad has equipped many miles of its New York end with an elaborate overhead structure strong enough to run electric engines drawing long express- and even its heaviest freight-trains. The power is here taken

from an overhead wire. On the New York Central Railroad the same principle is applied, but this railroad does not have the overhead trolley-wire; it uses another method of receiving the electricity, known commonly as "the third rail," suspended a few inches above the ground and supported by brackets fastened to the regular ties from which it is insulated. Along the under side of this rail runs a "shoe" of the locomotive that conducts the electricity from the rail to the motors of the engine.

Now before we go any further, let us stop for a moment to review.

You are all familiar with some of the things you can do with an electric battery. You know that by taking the wire that comes from a battery and connecting it with a little electric lamp, and then connecting the wire that comes out of the lamp with the other end of the battery, the lamp will flash up brightly. If you connect a little toy motor instead of the lamp, the motor will begin to buzz as soon as it is connected. Now, in electric railways, instead of a battery, they make the electricity by a huge machine called a dynamo, driven by a powerful steam-engine; and they connect the street trolley-cars or the electric trains with the dynamo current, to make the trains go, just as the battery current made the toy motor buzz.

The big dynamo and the steam-engine that drives it are not on the trains, but are stationary in the "power-house," and the current from the dynamo is connected to the trolley-wire that is suspended along over the tracks of the street or railroad. The long trolley that you have often seen is always touching this trolley-wire, and takes the electricity from it down to the motor under the car and starts up the motor; and thus the train (or trolley-car) is made to move.

To get an idea of what this electricity is, it may help us to think of it as a force that we have disturbed but which naturally seeks to be at rest. You may be aided in forming a mental picture of this condition by comparing it with a piece of rubber band which, under the force of your hands, is pulled out, and which when you cease to apply the force at once resumes its natural position. There are two "kinds" of electricity, the "positive" and the "negative." These two may be pulled apart, say, by the mechanical force operating a dynamo, and when separated are always eager to become again united. That ef-

fort to unite is power that may be applied through a motor to move wheels, near the separating force (the engine), or that may be carried to long distances through a circuit of wire or of metal rail in connection with the earth. The power is always striving to get back to that "home" machine, the dynamo, from which it

of water passing through, or the capacity of the pipe or hose.

The New York, New Haven & Hartford Railroad uses eleven thousand volts overhead "alternating" current, while the New York Central Railroad has about six hundred and fifty volts direct current. Each system has some advantages and some disadvantages, and consequently experts differ in their opinion and preference of the two methods. It is only actual and continued use that will decide which system is the better, all things considered.

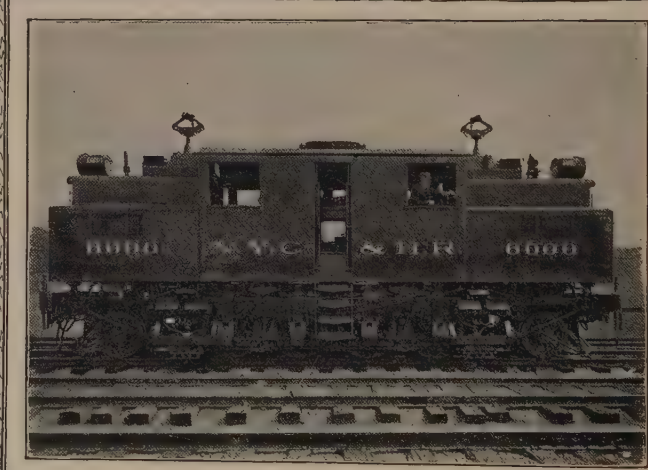
Electricity will always "hasten home," or to the source or the machine from which it started, by the path of least resistance, or, in other words, by the easiest way. If we want it to go to a certain place, we must compel it to stay on the wire, and not let it run off into the ground and so return to



AN ELECTRIC LOCOMOTIVE OF THE
NEW YORK, NEW HAVEN &
HARTFORD RAILROAD.

started, just as each end of the extended rubber is trying to go toward the hand that is pulling the opposite end. Where the current of electricity is slight, as in a telephone-wire, the complete circuit may be of wire for the best results, but the current may also go home through the earth; that is, may be "grounded," as the electrician calls it. With all trolley-cars and electric engines, this home circuit is through the rails. There is some leakage through the earth, but electricians try to avoid this by good connections with the rails.

The electrician measures the size or *volume* of this force in "amperes," and its intensity or *pressure* in "volts." If we should compare the "current" of electricity with a current of water in a pipe or hose, the voltage would be the strain exerted on the strength of the pipe or hose that holds it, and the amperage would be the amount



AN ELECTRIC LOCOMOTIVE OF THE NEW YORK CENTRAL RAILROAD.

the starting-point, as it will do if not carefully controlled. The current of an overhead system is prevented from getting back home without doing work (that is, from going down the iron posts and back through the earth) by a porcelain cap on the top of the post under the wires. These are the insulators. Electricity cannot pass through porcelain, glass, or some other "non-conductors,"

and is, therefore, compelled to stay on the wire. The under side of these insulators is curve "roofed" so as to keep a dry surface even in wet weather. This prevents the electricity from



THE "BOND" OF WIRES CONNECTING THE ENDS OF THE RAILS.

The iron clamp is not a good conductor on account of the rust between it and the rails.

"leaking" through a thin film of water in wet weather, as it would, because water is a good conductor of electricity. Sometimes the current is so powerful that it burns out the wire where it rests on the cap. To keep this from falling



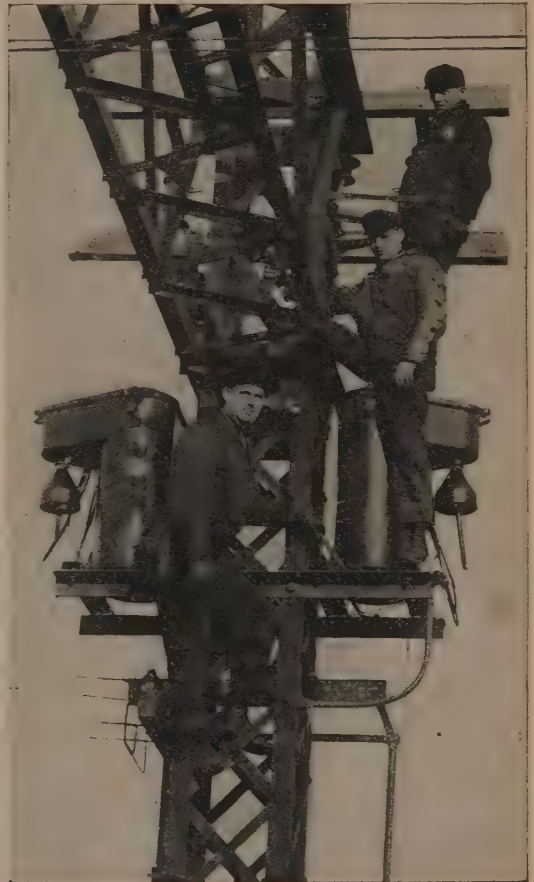
THE GLISTENING PORCELAIN INSULATORS.

The roofed "caps" are on the crossbars. On both sides of each of these are two insulators on the safety wire.

there is, in the New Haven overhead system, a safety wire, on which are four insulators. These

are the conspicuous, glistening balls that have no doubt often attracted the attention of boys and girls who travel by that road.

When the high voltage is to be reduced so as to be used in incandescent lamps as, for example, in lighting the station, a "transformer" is put up as shown in the illustration. This changes or *reduces* the original eleven thousand volts to a lower voltage for the motors and to one hundred and fifteen volts used for lighting.



PUTTING UP TRANSFORMERS.

These are the barrel-like objects with side-projecting tops. The transformers reduce 11,000 volts for power to 115 volts for the incandescent lamps in the station.

In an electric train, on the New York, New Haven & Hartford Railroad, the engineer with his hand on a lever sits at an apparatus known as the master controller (see illustration). At the upper end of this controller are knobs, like push-buttons, that control various parts of the engine—thus, one of these "buttons" raises or lowers the jointed framework (known as a pantagraph—a "railroad" form of the familiar trolley)



"THE ENGINEER WITH HIS HAND ON A LEVER SITS AT . . . 'THE MASTER CONTROLLER.'"

above the engine that when extended connects with the overhead power wire; another operates the "shoe" connected with the third rail; another controls the "sanders" to pour sand on the track if the rails are slippery.

Others of these knobs control the currents to the motors, of which there are four—one attached directly to each wheel without any gearing.

The locomotive contains much massive machinery, in addition to the motors, in the way of switches and of transformers for reducing the voltage of current as may be needed. At one end is a water-tank and a boiler for making steam with which to heat the cars.

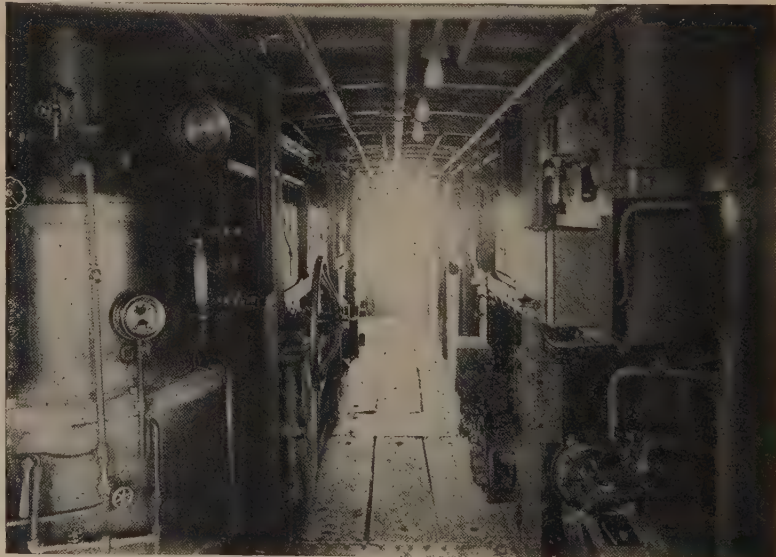
On the New Haven road, the ordinary electric locomotives are intended to pull loads of two hundred tons. Three quarters of the trains come within that weight, and it has been found to be cheaper to put two electric engines on the few heavier trains than to build and maintain larger ones. The placing of two electric engines on some trains was, therefore, not a mistake, as some have supposed, but simply a matter of economy. One engine can pull an express of four hundred tons, but it is easier for the engine and more economical for the company to have it done by two. To run

an express takes much less power in proportion to the size of the train than to run an accommodation, because it is much easier to keep the train in motion than it is to start and stop it. But while the express costs less for power, that is offset by the fact that it costs more in the greater strain on the rails and the machinery, and for the more expensive cars. When the traveler must ride for a long time he insists on having a better car than for only a short trip.

There are many who predict that the experiments in progress on these two roads, in electricity as a motive power, have been so successful that the method will ultimately extend to all others. Indeed, some people say that the power will not be obtained by burning coal, but from waterfalls. Who knows but that there will be overhead wires on all country roads and no engines, merely motors, in automobiles? Then steam locomotives or horses will be curiosities, or, at least, decidedly rare. The delightful fairylands of science seem to have been enlarged within the last few years so as to include nearly all methods of transportation.

But in predictions in the realm of scientific achievement, and in building up fancies therefrom, one hardly knows where to stop.

When work was first started on the Pennsyl-



INSIDE AN ELECTRIC LOCOMOTIVE ON THE NEW HAVEN RAILROAD.

At the left is the boiler to furnish steam for heating the cars. At the right is shown a part of the water-tank. The other machinery consists of transformers, switches, cylinders of compressed air, sanders, etc.

vania tunnels and station at Thirty-fourth Street, New York City, the engineers of the railroad company, cooperating with those of the Westinghouse Electric & Manufacturing Company, took

up the problem of designing an electric locomotive which would cope successfully with the heavy grades necessary in the tunnels under the Hudson and the East rivers. Much electrical apparatus was built and a mass of reports and records was compiled before the completion of No. 3998, the

and all other gear are spring-supported from the driver and truck-wheels, so that there is no track stress other than that pertaining to a single pair of wheels.

Earlier types of electric locomotives do not possess these features, the purpose of which is to



AN ELECTRIC LOCOMOTIVE ON THE PENNSYLVANIA RAILROAD THAT DRAWS THE TRAINS THROUGH THE TUNNEL UNDER THE HUDSON RIVER.

first "Pennsylvania" type of electric locomotive to be finished.

This locomotive weighs 330,000 pounds. It develops 4000 horse-power—about three times as much as a giant freight-locomotive—and it can pull a heavy freight-train at a speed of some sixty or seventy miles an hour. In appearance it is similar to two passenger-coaches, with huge driving-wheels and rods. On each side of the steel cabins are ten square windows, while at the ends there are oblong windows similar in appearance to steamship port-holes. The cabins conceal the giant motors with which the driving-rods connect.

The Pennsylvania-type locomotive is built in two sections; that is, there are two cabs and two running-gears, jointed at the middle. Each section has eight wheels, four of which are drivers.

The sections are permanently coupled, back to back, so that the leading section effectually pilots the rear one. This does away with all necessity of turning the engine, as it runs equally well in either direction, and all manipulating levers are duplicated in each section, so the operator simply changes from one end of the locomotive to the other.

This locomotive delivers no more shock to the track and road-bed than a passenger-car of equal weight. The motor and massive side frames

utilize on the drive-wheels directly the naturally continuous rotation of the electric motor.

A decided improvement in the Pennsylvania type is the use of a single motor for two pairs of drivers, and the benefits secured by its position. The motor is located high up from the road-bed, secure from snow, dirt, and water, and space limitations are largely removed. In its design it possesses electrical features never before secured on an electric locomotive.

The single motor weighs, without gear, 45,000 pounds, and in weight and power it is the largest railway motor ever constructed. It projects into the cab and, in fact, fills a large part of it.

The main control apparatus is in a bulkhead sort of an arrangement centrally located, so that there are ample passageways along the sides. At one end is located the electrically driven air-compressor for operating the air-brakes.

In the operating end of the locomotive there is a Westinghouse brake-valve for high-speed brake operation, and also the engineer's controller. These correspond to the throttle and reverse lever on a steam-locomotive.

The controller on the Pennsylvania type is scarcely as large as that on a Hoe printing-press. None of the main power passes through it, as it is really a switch corresponding to a telegrapher's key. With this small lever which can be easily

moved with one finger, the engineer can admit to the locomotive a current of electricity equal to that available in a hundred trolley-cars.

The electric supply is secured from an electric conductor, or third rail, by four contact-shoes on each locomotive. At some points where the great number of track switches will not permit this, power will be secured from an overhead conductor through an air-operated overhead contact-shoe, of which there are two on each locomotive.

The new locomotive is of steel construction throughout, and each section has the usual bell, sand-box, and a whistle which is blown by air.

THE TROLLEY-CAR ELECTRIC HEATER

IN order to produce heat, some kind of work must be done; for instance, when you run or jump or exercise violently you become heated. This is because you do a certain amount of work.



ONE FORM OF ELECTRIC CAR-HEATER. A LARGE AMOUNT OF LOW-RESISTANCE WIRE ON A SUPPORT.

Another example that might be taken is a rapidly revolving wheel. You boys and girls all know that if you hold your hand on such a wheel lightly, you can keep it there; but if you bear down at all, your hand will become so hot that you will draw it away quickly. This latter example is much the same as heating by electricity. Electricity, many of you know, of course, has to have a conductor which has to be metallic. When you wish to make a good deal of electricity go through the conductor, or wire, you use a conductor which will not impede its progress, or, speaking in electrical terms, one of low resistance, and, like the example of holding the hand only lightly on the swiftly moving wheel, will not cause the electricity to generate any heat.

If, on the other hand, we should use a conductor which would impede the flow of electricity, or, again speaking in electrical terms, one of high resistance, we will cause the electricity to generate heat in its effort to travel along the wire. The more resistance offered to the flow of electricity, that is, the higher the re-

sistance of the conductor used, the more heat we obtain for a given flow of current. But, going back to the wheel example, if we should hold our hand on the wheel and keep bearing down we would in time stop the wheel, unless additional power is expended to keep the wheel turning. This is the same with the electrical current. If we use a conductor of high enough resistance, which corresponds to bearing down on the wheel, we would stop the flow of current almost entirely unless extra power or electrical energy were applied to keep the current flowing. This would mean an increase in the voltage necessary.

What, then, is voltage? The term is familiar.

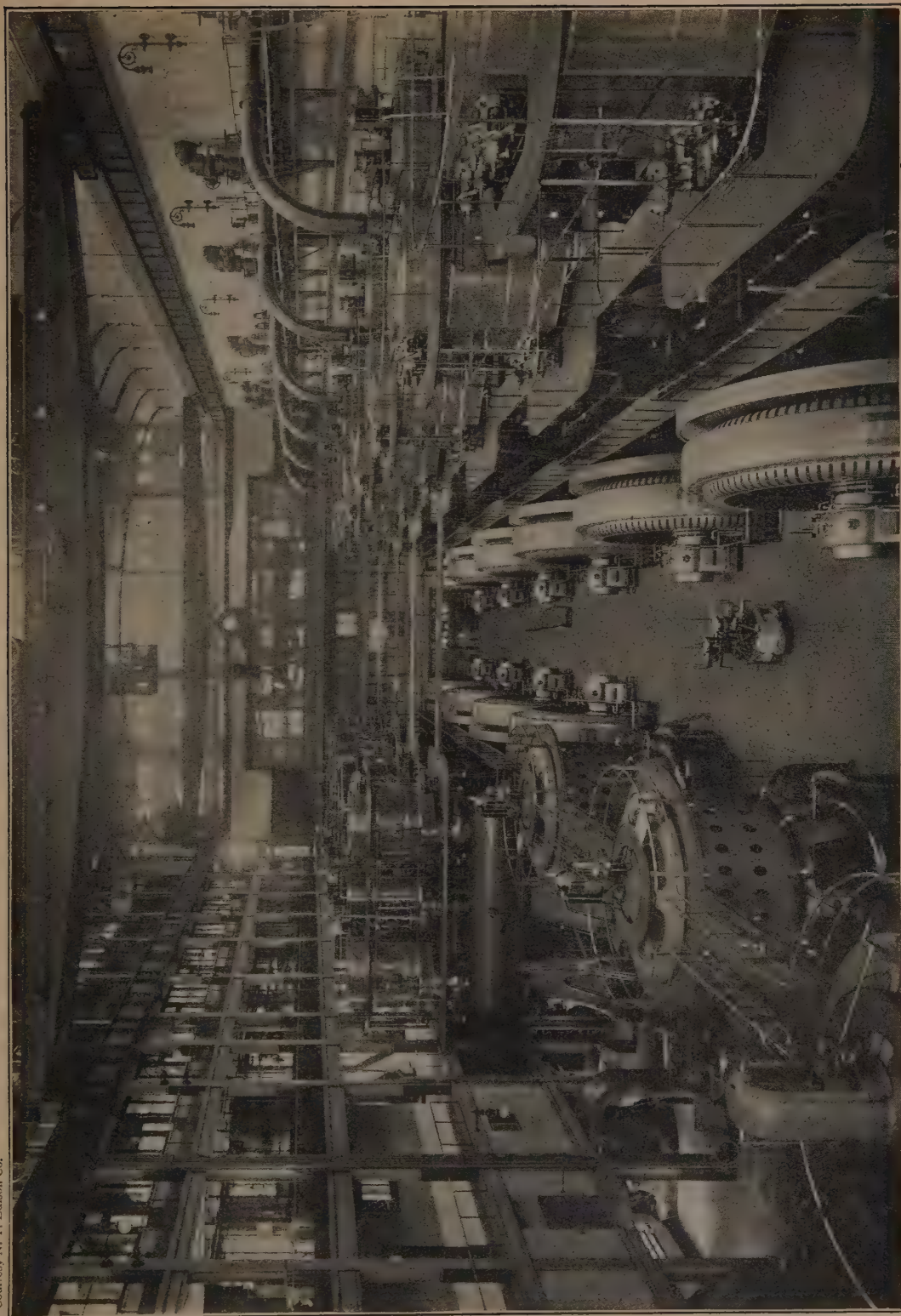
You all know that to force water through a pipe requires a certain pressure, and the smaller the pipe the higher is the water pressure required to keep the water moving. In other words, water pressure corresponds to electrical voltage, and the amount of water flowing corresponds to the amount of electrical current, or amperes, flowing. You will therefore see that in order to generate a great deal of heat we will have to use a certain amount of current and also have to offer resistance to its flow, maintaining sufficient voltage in order to keep it flowing, as the heat depends upon the amount of current forced through the wire.

In one of the commercial car-heaters the resistance-coil is wound upon a porcelain support, and a coil of great length is used. This aids in getting the heat out into the surrounding air, as the greater the heating surface the more heat will be radiated.



ANOTHER FORM OF ELECTRIC HEATER TO GO IN CROSS-SEAT CARS.

On account of the absolute cleanliness of the apparatus, the ease of turning on the heat with an electric switch, and the extreme light weight of the heaters, electric heating is coming into use very rapidly.—THOMAS FARMER, JR.



DYNAMO-ELECTRIC MACHINES, WATERSIDE STATION 1, NEW YORK EDISON COMPANY.

RUBBER AND ITS USES

A LITTLE beetle has changed the world. If there did not exist a certain wood-boring beetle which trees and creeping plants hate, there would be no automobiles in the world, no bicycles, no waterproofs, no telegraph cables under the sea. It is because certain trees and plants have the power to make themselves objectionable to insects that we are able to obtain one of the most wonderful materials in the world—india-rubber. What, then, is this wonderful substance which means so much to men and is so important for the future of the world?

It is simply a resinous, milky substance contained in rubber plants and trees. These are tropical plants found in South America, Africa, Ceylon, Mexico, and other warm, damp regions. There are many kinds of trees and plants whose juices contain the caoutchouc, or india-rubber, which is in the form of minute globules. The finest grades come from the forests of Brazil, especially from the State of Para. Not only are there trees that furnish rubber, but vines and bushes, and it is to be found in small amounts in varieties of our ordinary milkweed. But it is the tree that supplies the best rubber, and to-day white men are making extensive rubber plantations in various parts of the world. The trees are set out and carefully watched, and at maturity yield rubber abundantly. In their wild state these trees live in hot, damp, tropical forests where there are swarms of wood-boring beetles. Now, instead of having ants to protect them, as some trees have, and instead of being armed with bristles or thorns, as so many trees are, these trees have a poisonous, sticky juice. As soon as a beetle thrusts its boring weapon into the bark, the tree pours forth this juice.

It kills the insect, and at the same time fills up the wound which has been caused. If the substance dried hard, like clay or putty, it would be forced out of position when the tree was blown to and fro by the wind. That would leave the wound open, so that the beetles might again attack it; while the spores of deadly fungus might find a resting-place in the wound, and gradually kill the tree. But this juice, when it dries, is elastic, and, no matter how the tree sways in the wind, it still holds itself in place, safeguarding the tree against further injury from the wound which the wood-boring beetle has caused.

It was not the wise people of Europe who first discovered that this substance which protects the tree from insects might be useful to man. Columbus found the natives of Haiti playing with balls made of it when he discovered their island; and

a traveler named Torquemada noticed, four hundred years ago, that the Mexican Indians used the same substance for making their cloaks waterproof.

The substance which was to work such wonders in science and industry in the Old World was brought first from the New World for the very purpose to which children and artists still put it: india-rubber was a rubber and nothing else. Somebody discovered that it would remove pencil-marks from paper, and the fact was noted by Joseph Priestley, the discoverer of oxygen, as early as 1770. It came into general use for that purpose about 1820. The rubber was invaluable to artists for removing false marks from their sketches. Charles MacIntosh, a thoughtful Scotsman, was the first white man to put rubber to the use which the Indians had made of it. He used it to make waterproof coats, which are called mackintoshes, after him. Then it was discovered that rubber, which would withstand the effects of water, could not be penetrated by gas, and that the majority of other liquids, in addition to water, could not make their way through it. So surgeons had it made up into tubes. But the great discovery was yet to come.

In its natural state rubber becomes solid under the influence of cold, and soft and sticky under the influence of heat. While waterproof boots and shoes were made of the crude gum, they were unsatisfactory. An American named Charles Goodyear was the first to discover that all this could be altered by adding sulphur which has been melted by heat. Goodyear found that one of his associates had sprinkled powdered sulphur on rubber which he dried in the sun, and noticed that the effect was the same as when acid was used. Accidentally, some of this was dropped on the top of a hot stove, and the riddle was solved. Soon he mastered the process which is known as vulcanizing, and this has proved of great value.

By vulcanizing we can convert pure rubber into a substance which not only loses its sticky properties, but is more elastic, less soluble, and less affected by temperature. From vulcanized rubber, soft and elastic, we can make almost anything—springs for automobiles and carriages, rubber boots and shoes of all kinds, hose for the garden and the fire department, bouncing-balls, hot-water bottles—an infinite variety of useful articles. Large amounts of sulphur are added to produce hard rubber, and we can make a substance that will resemble ebony. The black disks of which the gramophone records are made, are of vulcanite; so are the black mouthpieces of tobacco-pipes, the trays which we use for the

solutions in photography, and a thousand other things that we use every day.

For ten years Goodyear worked at the task of perfecting his invention, and sadly did he suffer from scoffers at the time. He conquered in the end, after bitter suffering and poverty, and by 1844 he was triumphant. In prison for debt, selling his children's school-books for money to carry on his experiments, he yet by his persistence conquered and a great industry was founded. At about the same time a man named Thomas Hancock was at work on the same idea in England; so that two different men, in different parts of the world, were working at the same scheme at the same time, as has been the case with many discoveries and inventions.

Let us for a moment think only of rubber boots and shoes, and the manufacture of hose, as two great fields of the rubber industry. Without these articles we would turn back to the days of oiled boots, and of the cumbrous leather riveted or sewed hose used by the hand fire-engine of the eighteenth century.

Furthermore, it was this newly treated rubber that first made bicycling possible. There had been cycles long before—hobby-horses, and different velocipedes, and other things of similar style. The rubber tire gave them new form, new life and dignity, for the first time. But the old tall bicycles and the first "safeties" had small and solid rubber tires. How they jolted and jarred along the stony roads, carrying the rider home with his teeth aching and his wrists almost shattered! Automobiles could never have run with tires of this sort, for the bumping over even the very best of roads would simply have jarred and shivered the engines to pieces in a short time.

Happily, in the last quarter of the nineteenth century J. B. Dunlop, of Dublin, thought out the grand idea of making an air-cushion for a bicycle tire. He was a long time working at it, and at first he fitted one on a block of wood, and trundled that about his yard. It answered all right, so he made and fitted a tire of this sort to his own bicycle, then put one on the machine of his son, enabling the boy to win a race for which he had entered. The principle of the first Dunlop

tire was the same as that which makes the automobile or bicycle ride so delightfully to-day. The inner tube is made of comparatively soft, thin rubber. It is that which we blow up with wind. The cover which fits over that is stout and hard. That simply serves to protect the inner tube from injury. It is that tube filled with air beneath the cover which has worked the marvel. The wheels of the bicycle or car actually run on the compressed air in the pneumatic tube. And it is this that makes possible their high speed. The pneumatic tire grips the road-surface without slip, and no shock is communicated to engine or springs on any good road. For the heavy commercial trucks and fire-engines we need heavy tires, which are usually solid, but they too must be made of rubber, for as yet we have evolved no satisfactory substitute.

The invention of the rubber tire has gone all over the earth. In every civilized country there are cycles and automobiles using these wonderful tires. This little tube of air has made perhaps the greatest revolution of modern times. Places where there are no railways are now visited as easily as if Ariel had given us his wings.

With the increased uses of india-rubber come new and increased applications. In electrical work we find india-rubber used as a valuable insulating material, and taking the place of the more expensive and rarer gutta-percha for underground and submarine cables. With machinery, cotton belts saturated with rubber are used in place of leather. In one form or other rubber enters extensively into almost all science and manufacturing. Not only are large plantations being started with small rubber-trees, under artificial cultivation, but extensive explorations are going on with a view to determining new supplies of the raw material. In South America and Africa the rubber-forests, and the relation of the natives to the industry, have been more than once the occasion of political disturbances that have almost resulted in war. But in the end scientific methods of growth as well as of manufacture will triumph. The cultivation of india-rubber will be carried on, not by ignorant natives, but by well-trained and scientific planters.



QUEER THINGS ABOUT EXPLOSIVES

BY WILLIAM R. STEWART

ABSENT-MINDED persons had better let explosives alone. Unconscious carelessness, too, is something that must be guarded against. We all know how we frequently forget whether we have wound a watch or closed a door, to find on investigation that we have done so, but entirely un-

to any combustible substance combined with sufficient oxygen to burn the combustible. The explosion comes whenever, by whatever agency, its various parts are broken from one another, or made to react on one another, resulting in the formation of a gas occupying several hundred



SEVERAL EXPLOSIONS UNDER WATER, ALONG SHORE, ALL AT ONCE.

Courtesy of "The Technical World Magazine."

consciously. When explosives are being handled one must n't forget what is going on.

And yet a popular notion that explosives will "go off" by any simple method is wrong. Many of the most powerful explosives imaginable may be kicked about, may be set on fire, or may be shot out of a gun, and unless the proper agency for exploding them is employed, they will not "go off" and will do no damage.

The reason for this may be explained by an illustration. Consider a grate full of coal. There is there enough of what we may call explosive energy to throw a 1000-pound weight through a foot of solid steel—if only it could be liberated. But there can be no explosion without oxygen, and the coal in the grate will not burn faster than the supply of oxygen in the air which reaches it will permit. If the coal could be furnished, *all at once*, with enough air to cause its complete burning, it would explode with as great violence as if it were so much dynamite.

The term "explosive," it therefore will be seen, is a very comprehensive one, and can be applied

times more space than the original material, and at the same time developing a high temperature by which its expansive force is much increased.

I remember well one time visiting Hudson Maxim, the inventor of "maximite," at his home in Brooklyn, New York, and being astonished to see him, for the entertainment of a caller, calmly lighting a cigar with a stick of dynamite. On my expressing surprise that the dynamite did not explode, Mr. Maxim took another stick and proceeded to use it as a hammer to drive a nail into a hardwood plank. Not content with that, he next cut a piece off, like so much wood, with a carpenter's saw, and, that done, insisted on cooking us a welsh rabbit in a chafing-dish over a lamp filled with nitroglycerin. The explanation simply was that not sufficient heat was produced in any case to break up the parts of the explosive compound.

There are two ways in which an explosive may be "set off"—by burning and by detonation. The burning process is progressive from one particle to another—as of fire in a grate, only infinitely

more rapid. This process is adapted to gunpowder, requiring as it does a very short time for the burning-up of the explosive body. The other form of explosion—the detonative—being at once throughout the mass, is unfitted for use in guns (which would be smashed to pieces), but is adapted to shattering, or breaking, purposes, such as blasting rocks in mining operations and bursting charges in shells, torpedoes, and submarine mines. Substances of the latter sort are termed high explosives.

Some examples may be given of the safety with which the most dangerous explosives may ordinarily be handled. For instance, a considerable quantity of guncotton (such as pure cotton treated with nitric acid) may be set on fire, and will burn quietly. But if a sufficient mass be set on fire the heat and pressure on the surface of the burning body will cause the whole to be exploded. A torpedo filled with wet compressed guncotton will not explode if a shell from a cannon should penetrate it and burst in the mass of guncotton. Even nitroglycerin will burn like oil in small

quantities; and a stick of nitrogelatin may be set on fire without danger of harm.

Most persons unfamiliar with the properties of explosives suppose that shells and submarine mines are dangerous in themselves and that to handle any of them would be courting death. As a matter of fact, however, the fulminating or "setting off" body which is required to be attached to the high explosive in the shell or the mine is the only ticklish part about the mechanism. Fulminate of mercury usually is used for this purpose, and it is made by dissolving mercury in nitric acid, to which solution, when cool, alcohol is added. Fulminate of mercury has a peculiar chemical make-up that adapts it to this purpose. It has been estimated that fulminate of mercury, when exploded in contact with a body, exerts a pressure of more than half a million pounds to the square inch. In other words, the fulminate used as a fuse strikes the high explosive a blow with a force of half a million pounds to the square inch. The explosive wave thus set up is too strong to be resisted by the



A NEAR VIEW OF HUGE UNDER-THE-WATER EXPLOSION.

Courtesy of "The Technical World Magazine."

chemical bonds of the body; and they are loudly broken apart.

Probably the most powerful high explosive



EXPLOSIVES APPLIED TO A HUGE STUMP
AND ROOTS OF A TREE.

Photograph by Arthur H. Green, with multi-speed shutter, in one-thousandth second.

compound in use is that which has been adopted by the United States government as a bursting-charge for shells. This explosive is about fifty

per cent. more powerful than ordinary dynamite and somewhat more powerful than pure nitroglycerin. Notwithstanding its high explosive property, however, it is but little affected by shock and will not explode from fire even if a mass of it be stirred with a red-hot iron. Heated in an open vessel it will evaporate like water, and shells for cannon are filled with it by the simple process of melting and pouring. This explosive, like the high explosives in use in European armies and navies, is a compound of picric acid, but its real make-up is secret. Picric acid is obtained by treating phenol with strong nitric acid. These explosives can be "set off" only by special fuses, which also are government secrets.

Notwithstanding that the most powerful explosives may be handled with the greatest safety and have all sorts of pranks played upon them, provided their peculiarities are borne in mind, accidents in powder factories are of constant occurrence. This is largely because, not of the conscious carelessness of the workmen, but of the tendency for voluntary acts gradually to become automatic and therefore unconscious. It is this automatic and unconscious tendency that enables the agile fingers of the typewriter and the pianist to perform automatically, leaving the conscious mind to other duties. Thus the workman in the explosives manufactory, knowing the harmlessness of dynamite unless set off by a proper agency, is likely to neglect precautions which, from one cause or another, may be essential to safety. And even with the greatest care death always hovers about any one who works with the tools of death.

PATHWAYS IN THE AIR

No one can say who built the first bridge. Nature herself would no doubt be man's first teacher. Man would find a path across a chasm by clinging to a twisted vine; or he would see a ready-made bridge consisting of a fallen tree-trunk across a stream. Those were the first bridges, and they were the sort which would have to be made for hundreds of years.

One day a genius arose, who dumped high heaps of stone in a line across a stream, and on the top of these placed slabs of slate or stone or fallen trees. Then, a long, long while afterward, came bigger, real bridges. The Romans were the first to learn how to make these. They built splendid bridges on arches, some of which exist to-day.

Men had a long time to wait before they got good bridges in England. The twelfth century had almost ended when the first great London Bridge was built. There were wooden houses and shops on it, but these were always catching fire and damaging the bridge, and they were all pulled down before the bridge was destroyed.

A great reform was made in bridge-building by John Rennie. It had been customary to make the arches very high, so that the roadway sloped very sharply up on one side, and very sharply down on the other. But John Rennie made his arches, not like the half of a circle, but like the half of an egg, cut lengthwise.

There still exists a famous single-arch bridge of the old type, the famous bridge at Pontypridd,



BRIDGE WORKERS AT THEIR DANGEROUS TASKS.

These pictures (excepting the one in the lower left-hand corner) were taken of workers on the Queensboro Bridge, New York City, during its construction, 1901-09. The two upper pictures show the placing of a great upright and a cross-beam in position. In the lower left-hand picture a man is shown painting the cables on the Brooklyn Bridge; and in the right-hand picture a photographer is seen at work on a girder.

in Glamorganshire, Wales. The first bridge there had three arches, but the river washed them away. Then the builder, William Edwards, put up another in its place, but it had only one arch, and soon fell.

Edwards discovered the cause of its fall. There had been too much weight on the supports, and not enough in the center. By being too light on top, the crown of the bridge was forced up and made to fall. Then he built a third bridge, in which the haunches were lighter and the top heavier. That bridge still stands, after being used for more than 150 years.

When the eighteenth century was drawing to a close, men began to build bridges of cast iron. But engineers soon found that, though cast iron can bear great pressure, it will not bear much pull. It cannot be easily crushed by a weight, but it can soon be snapped by weights which pull at the two ends. So they then used wrought iron, which cannot easily be pulled apart. That served until steel came into use in the nineteenth century.

The first great bridge built of wrought iron was the Britannia Bridge, which crosses the Menai Straits in North Wales. The builder was Robert Stephenson. He made a huge square tube of iron—iron at the top, iron at the sides, iron at the bottom—and through this tube of iron the trains pass. To increase the strength of the bridge he made the iron at the top and bottom tube-shaped, instead of solid, because it would better stand the pull of the weight.

THE GREAT IRON TUBES IN WHICH THE TRAIN CROSSES THE WATER

THESE tubes are built on huge columns of masonry, one being founded on an island halfway across the water, and the others on the land at the sides. As ships were constantly passing, it was impossible to put up great scaffolds on which to build up the ironwork. So Stephenson had the two tubes, nearly 500 yards long, built in four sections on shore. When all was ready the big tubes were floated on many boats, and ferried out to the towers.

As the tide went down the boats gradually sank, and the tubes, weighing 5000 tons each, came to rest in grooves prepared for them in the masonry. Then the boats were drawn away and the enormous masses of iron were hoisted up to the proper height, 100 feet above the water, by great engines.

The finest of all bridges is the great steel cantilever bridge. A cantilever is copied from the oldest of simple bridges. If two trees lean over

the water from different sides of a stream we have only to run a plank from the end of one trunk to the end of the other, to make a simple cantilever bridge. That is one way of applying it. The other is to consider the cantilever a bracket. Secured firmly at one end, a bracket will bear a shelf with a heavy weight of books, and the steel cantilevers forming a bridge are merely huge brackets.

A GREAT BRIDGE-BUILDER WHO DIED BROKEN-HEARTED

THERE had been many schemes for bridging the river Forth, and at last the work was begun by Sir Thomas Bouch, who had built the famous Tay Bridge. But suddenly, one dreadful night in the winter of 1879, part of the Tay Bridge was blown down, carrying with it into the river a trainload of people. Everybody in the train was drowned, and the country was horrified. Sir Thomas Bouch died broken-hearted, and the Forth Bridge was designed by Sir John Fowler and Sir Benjamin Baker.

They had to cross two swift channels of water. There is an island in the middle, but on each side of it there flows a channel of water deep and swift, and 1700 feet broad. It was impossible to sink piers in these channels, so the central pier was founded on the island, and two others built nearer the shores.

The cantilevers, of which there are three pairs, carry the bridge across the two wide stretches of water. They are each 1360 feet long, and the three, stretching out toward each other, leave a space of 350 feet to be covered between the ends of the first and second, and a similar space between the ends of the second and third. Here ordinary steel girders are used. In order that ships may pass under it, the bridge is made 150 feet above high tide, and its top parts are 361 feet above the water.

The cantilever-bridge plan has since been used for many other bridges. One on this plan crosses Niagara at a great height above the water. The cantilever is used in suspension bridges also. Huge columns are erected on land, and from them chains or wire ropes are stretched across the gulf, carrying a roadway.

KITES AND ROCKETS USED FOR BUILDING GREAT BRIDGES

THE best suspension bridge in England is at Clifton. This is 702 feet across, and 31 feet wide. It is more than 200 feet above the river Avon, and it is said that the first string attached

to the rope which pulled across the cable was sent over by a kite.

A still stranger way was adopted for starting the great bridge across the Zambesi River, in South Africa. The bridge is the highest in the world—400 feet above the water—and runs from cliff to cliff; so they had to fire a rocket fastened to the end of a cord. The rocket took the cord across, the cord was used for hauling across a wire, and the wire was used to pull over a small cable. On this a truck crossed carrying the main cable of the bridge, which is 200 yards long, and the greatest engineering wonder in South Africa.

The Tower Bridge, in London, is 800 feet long. When a ship is too high to pass under, great machines cause the roadway to open in the middle. The two halves are pulled up, working on enormous hinges, and the ship passes through.

THE BUILDING OF MODERN BRIDGES A SCIENCE

THE building of great bridges has been becoming more and more a matter of science with the need that they shall be fitted to carry the enormous loads that are put upon them by modern railways. It was soon found that a bridge which was able to carry very great weights at long intervals, must be much stronger if that same weight is to be put upon it at very short intervals, as happens in the running of many railway trains without a chance for the bridge to come to a complete rest between them.

Thus, as bridges were needed for the thousands of railways built since 1830, and it was necessary to make these both strong and cheap, the engineers had to find out the strongest and best materials. As iron had replaced wood, so steel took the place of iron; and now bridges are largely being built of concrete in which steel is imbedded to prevent the concrete from breaking under pressure or strain.

If a bridge is built so that the road rests on an arch, then the material bears a downward pressure, and the material must resist crushing. If it is built so that the road is hung from supports, the material will have to resist a pull or strain. The first kind makes a stiff bridge; the second is flexible. Yet both must be so made as to yield a little to the weights on them, and to allow for the changes that come when the heat of summer and the cold of winter make the parts expand or contract. It is necessary also to provide that the wind-pressure shall not bring on the bridge a strain that will wreck it, even when there comes a hurricane.

All such matters must be thought out, and most carefully calculated; and the engineer has to fix the size and shape and the place of every one of the parts that go to the making of the great structure, often hundreds of feet high and more than a mile long. The cost of all work, all material, everything that assists in the construction has to be planned for, and often what is spent on one part must be saved on another. For this reason, the building of great bridges has come to be done usually by great companies that know just where every strain or push comes, and how it can best be provided against.

Every bridge is a new problem. In some cases a wide span is best, in others a number of short spans; some bridges must admit of being opened or raised so that vessels may pass; others must remain high in air, as over the East River, New York, so that the river may always be open below. And, besides being useful, it is often required also that bridges shall be as beautiful as possible.

Remembering these things, you will find that if you come to think about the different bridges you see, you will learn that each has its own interest and character, and each has much to tell you about why it is built in one way and not in another. Every bridge has its story, and many of the stories are romantic and exciting. You need not visit them in order to make their acquaintance, it is enough to see them in pictures, and to notice how one differs from another, and why.

The little Alpine bridge over a mountain stream; the great stone causeway that leads over a ravine to an old castle; the light narrow footway that serves the Hindu peasant; the railway bridge over which are four railway tracks; the drawbridges, the hoist-bridges—all differ for good reasons, and all tell their purpose to one who will but think and inquire.

Among the newest kinds is that known as the "transporter bridge." This, in its earliest form, is a great rope or wire stretched over a stream or chasm, along which a suspended net or a basket can be drawn to carry things or people. Children who are neighbors often stretch a cord between their houses, and send notes or little presents to and fro in a basket. A transporter bridge is only a strong framework along which a hanging car is run by electricity (as the basket is moved on the cord) to carry passengers and freight. As these bridges are not expensive to build, and do not obstruct rivers, they are likely to be used where there is no need for a fixed roadway.

From the earliest times the builders of bridges were held in high honor, and even to-day the



1. MANHATTAN BRIDGE, NEW YORK. 2. STEEL ARCH BRIDGE, ST. LOUIS.
3. BROOKLYN BRIDGE, NEW YORK.

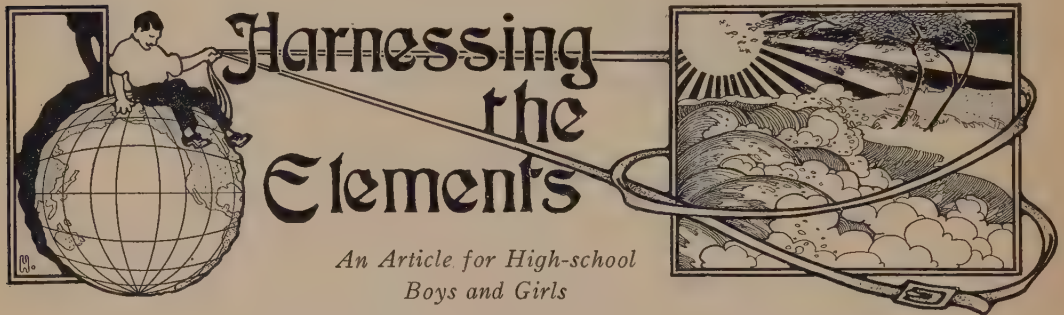


4. PORCUPINE BRIDGE, CANADIAN AND WESTERN R. R. 5. BRIDGE OVER NIAGARA RIVER, BELOW NIAGARA FALLS. 6. SUSPENSION BRIDGE, CHICAGO AND ALTON R. R.

Pope is known by the title "Pontifex Maximus," the meaning of which is "Greatest Bridge-builder," simply because the Romans intrusted the building of their bridges to the priests, and gave this title to the chief of the priesthood.

But proud as we should be of the pathways

man has built in the air, the best bridge-maker is the spider. She has so far remained without a rival, and until man shall sail from point to point in an aeroplane, leaving a bridge behind him to mark his path, the spider will remain "queen of bridge-builders."



*An Article for High-school
Boys and Girls*

BY GEORGE ETHELBERT WALSH

A MINING engineer of world-wide reputation was discoursing not long ago on the undeveloped resources of the world, and startled his audience with this bold statement:

"It is not gold, silver, nor copper—no, nor diamonds, either—that will make the great fortunes of the future. I've had a pretty thorough experience in prospecting for precious metals, and I tell you, gentlemen, that it is the hidden power in the air, water, and sunshine that will build up the colossal fortunes of the next few centuries."

Not long ago, at a meeting of the British Association of Scientists, an eminent engineer predicted that within twenty years the whole civilized world would be placed on an electrical basis. "We will," he said, "heat and light our homes with electricity; travel by it; cook our meals and manufacture our goods by the same power; navigate the air and water by electric propulsion; and even purify the air we breathe; and cure half the ills we are heir to, by the electric current. And this power will come, not from the coal-pile, but from water, air, and sunshine!"

Lord Kelvin, in speaking of the beauties and the vast energy of Niagara, said its power would be felt all round the world, and in a burst of enthusiasm he added: "But we must not forget our small streams and waterfalls, either. There is but a single Niagara; but there are tens of thousands of small streams and waterfalls capable of turning the wheels of commerce."

Just imagine all the great coal-mines of Pennsylvania, Ohio, Indiana, and Alabama bursting forth in an inextinguishable flame, burning night and day for years and centuries; then add to the conflagration the great oil-fields of Texas, California, and Pennsylvania. We might then get a faint idea, from this waste of coal and oil, of the waste in water-power that is going on continually all around us without so much as attracting our attention.

It is estimated that throughout the world about 2,000,000 electrical horse-power is generated to-day from waterfalls and streams. Over one quarter of this enormous horse-power is generated in the United States, with Canada second and Switzerland third.

What is 2,000,000 horse-power, and what would it represent in coal? At the lowest estimate it would require some 25,000,000 tons of coal to generate 2,000,000 horse-power continuously by the ordinary steam-engine; and allowing \$5 per ton for the cost of coal, this would represent a saving in our coal-bill of \$125,000,000.

THE WORLD'S WATER-POWER NOT IN USE

BUT the possibilities of our small streams make the dream of the future seem unreal and fantastic. No man has dared even to try to measure or compute the total undeveloped water-power of

the world. There are thousands of streams capable of producing from 100 to 50,000 or more horse-power; a few others, like Niagara, the Victoria Falls in South Africa, and innumerable falls of the Mississippi, the Colorado, and the Missouri, with powers in this direction that seem unlimited. What is the utmost strength of Niagara? If every part of the mighty torrent of water was harnessed, it would easily generate sufficient electrical power to do all the work of this country. We could almost belt the globe with horses, and still Niagara would stand a good chance to offset their pulling-strength. But Niagara is no greater than Victoria Falls in the heart of Africa—some say not so great in its unmeasured possibilities.

The value of a stream for power purposes depends upon the *amount* of water flowing, and also upon its "head," that is, the height of its fall, whether in a sudden cataract, or in rushing down a slope; and so the small mountain stream which tumbles noisily down steep slopes and gullies is often worth more than the broad, sluggish river that flows through low, level stretches of country. On the California coast a great many mountain streams, with little to recommend them otherwise, have been converted into sources of great wealth. The longest distance over which electric energy has been commercially transmitted is from the De Sabla power-house in the mountains to the town of Sausalito, opposite San Francisco, a total distance of 232 miles. Two other long-distance lines on the Pacific coast are the Colgate and Oakland transmission lines, 142 miles long, and the Electra, Stockton, San José, and San Francisco lines, 147 miles long. The power to send from 15,000 to 60,000 volts over such distances is derived, not from some great river, but from comparatively unimportant streams.

Imagine a brook, a few feet deep, pouring its waters into a long flume that conducts it 10,000 feet below to a power-house where turbines convert it into power sufficient to operate scores of factories or turn the wheels of a hundred miles of trolley-cars! Each cubic foot of water pouring down this flume would develop over a thousand horse-power per second. Can one think of any gold-, silver-, or diamond-mine yielding more valuable returns than this little insignificant mountain stream? One cubic foot of water per second may equal in energy the total stored energy of many tons of coal.

In large parts of New England, the South, and Middle and Western States there are innumerable small streams of water from 500 to 2000 feet above the sea-level. Each one of these rep-

resents commercial possibilities that surpass coal- and iron-mines in value. Any stream of water that has a fall of five feet per mile along its whole course may develop thousands of electrical horse-power.

The annual fall of rain and snow represents a layer of water in this country that would vary from two to five feet in depth. This rainfall must eventually reach the oceans, and its flow downward swells streams and rivers to overflowing. Stored in proper reservoirs, this waste rainfall could be converted into electrical power that would banish dirty coal from our homes. Then, when used for turning the turbine-wheels of great electrical power-plants, it could be used also for irrigation, and distributed over wide areas for increasing the fertility of our farms. More than this, electrical pumps, operated by the power which the flow of the water from its reservoirs generated, could distribute the water to new regions where ordinary irrigation ditches could not conduct it.

In other words, the water could be used twice, first for generating electric power, and second for irrigating our farms. Electricity could be made to light and heat the homes of the city and country population, and run the threshing-machines and reapers of the farmer as well as turn the wheels of the cars and factories.

POWER FROM THE WIND

As if this were not enough, nature has supplied other available sources of power in the wind and sun. The work of harnessing these two agencies for doing our work, or for heating and lighting our homes, has not progressed so far or satisfactorily as that of subduing the mighty cataract and awakening the little mountain stream.

In point of fact, the use of wind-power for mechanical purposes is older than that of any other. The windmill is one of the most primitive structures. Its origin goes back many centuries. But a windmill for electrical generation is one of the most recent of accomplishments. The first windmill electric plant ever installed in this or any other country was built privately by Dr. Charles F. Brush, the inventor of the arc-lamp, in 1889, at his home in Cleveland, for the purpose of lighting his house and laboratory.

Since this pioneer attempt to harness the wind for generating electricity, important improvements have been made in manufacturing storage batteries and electrical machinery. In Europe commercial windmill electrical plants have been built. One such plant established at Wittkeil, in

Schleswig, lights the town, and another windmill plant at Hamburg has been successfully used in running a factory. A windmill electric plant at Boyle Hall, Ardsley, in England, has a capacity for running 110 lights in winter.

The windmill electric plant found a new use in Nansen's polar trips. A complete windmill electric plant was installed on his ship "Fram," and in the northern latitudes electricity was thus obtained for lighting the ship during the long arctic nights. In that northern latitude, where coal and other fuels are more precious than gold, the electric windmill is a godsend, and in the future nearly all polar exploring ships will be equipped with this new invention. During the antarctic exploration of the ship "Discovery" a windmill electric plant proved one of the most precious possessions on board.

Out in the great, flat central plains, where streams are sluggish in their movements, and where fuel of all kinds is scarce and high-priced, the electric windmill should have a great future.

If the average wind-power the year round is steady, the operation of windmills is practical for generating electric current.

In the great prairie States, where dry weather in summer often withers up crops within a single week, the wind velocity in summer is constant and high. They are hot, dry winds, but their velocity is sufficient to keep thousands of windmills in steady operation night and day. The time may come when our big prairies will be dotted with windmills, somewhat as Holland is.

Thus the problem of irrigating the farms and supplying them with electrical energy for lighting and other purposes is easily solved. For these hot, dry winds that have in the past proved the greatest enemy to agriculture in the vast corn and wheat belts now become the greatest blessings. They can pump up the water from the underground reservoirs, and after being used for developing electrical energy it is distributed through irrigating ditches for feeding the crops with much-needed moisture.

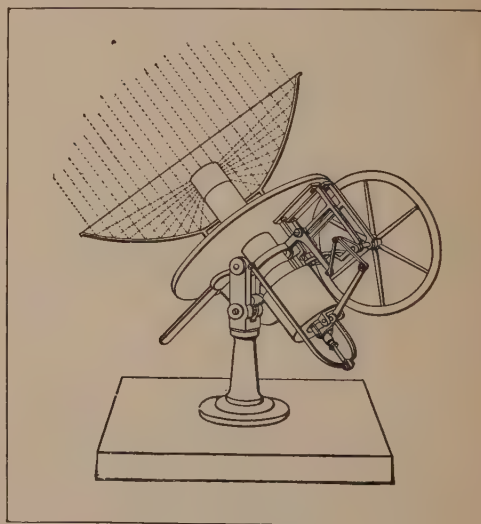
One windmill electrical plant should irrigate ten acres all through the summer, and a score of these could convert the desert into hundreds of acres of fertile gardens. On the California coast electrical pumps have raised the value of land from a few dollars an acre to \$200 and \$300 per acre. There is room for a million electrical windmill plants in the West, and with their installation there would be secured from the wind a new wealth valued at millions of dollars. The elements of the air are the agencies which perform the work for us, and man simply directs the use of the power as he needs it.

POWER FROM SUNSHINE

ELECTRIC power from sunlight appears more wonderful than harnessing the streams or wind. Yet we know something of the vast heat of the sun.

Solar engines for operating pumps have been in use in different parts of the earth for several years now, and their value in warm climates where the number of days of clear sunshine averages high must steadily increase. One of the most successful of these solar machines is located near Los Angeles to irrigate fruit-land. An automatic stand carrying great reflectors follows the course of the sun as regularly as the best telescope ever made, and the sun's rays are thus reflected on a central point where the boiler of a small engine is located. Within an hour after sunrise the heat of the sun raises the temperature of the water to the boiling-point, and thus creates steam; and the pumping machinery begins its day's work and keeps it up until sundown.

The power of the sun for heating has only been faintly appreciated by scientists in the past, but the prediction is made now that if all the coal should give out we would soon be able to run much of our machinery from the power of the



ERICSSON'S SOLAR ENGINE.

sun. With five hundred mirrors properly arranged to focus the rays upon one point, a temperature of more than a thousand degrees has been obtained. This almost equals one-fifth the highest temperature recorded by the electric furnace, which is considered to-day the most powerful heating apparatus ever discovered. As there is no limit to the number of mirrors that may be employed, and as the intensity of the heat in-

creases in proportion to the number of rays reflected by the mirrors, it is conceivable that a temperature may be obtained in time that will surpass anything ever dreamed of in the past or present.

Hitching the sun to run electric motors for

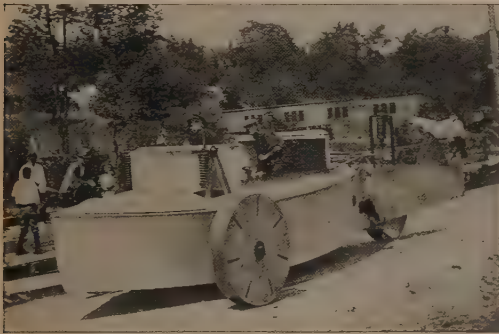
furnishing light and power for our homes and factories is the very latest achievement of the modern work of harnessing the elements to do man's work; and one square yard of sunshine in the tropics may represent, on the average, one horse-power.

AN AUTOMOBILE FOR WATER AND LAND

THERE appeared on the streets of Atlantic City not long ago one of the strangest vehicles ever seen. It looked as if its maker had attached a ten-foot tail to a motor-boat, and mounted it upon three broad wheels. This queer-looking craft made its way across the city, down to the

from turning. On coming out of the water the tail empties automatically.

More recently Admiral Howell has had a new and improved model built at Bath, Maine. Since



THE AUTOMOBILE ON THE STREET.

sandy beach. Here it turned about and, tail first, proceeded steadily through the surf out into the ocean. The new craft was named "Amphi," because it is amphibious; that is, it "lives" in water as on land.

This combined surf-boat and beach-automobile was invented by Rear-Admiral John A. Howell, United States Navy, who served all through both the Civil War and the Spanish-American War.

The body of the amphibian is much like the ordinary motor-boat. The long tail, which serves as a rudder in water, is its distinctive feature, and enables it to go through the heaviest surf without danger of capsizing. When a strong wave strikes the stern of the ordinary boat, it raises this stern from the water and tends to turn the boat around broadside; then, if caught in the forward rush of water caused by the breaking of the wave, the boat is overturned. Now the tail of the amphibian is hollow and fills with water on entering the sea. As it has no surplus buoyancy, its centerboard remains deep in unbroken water, thus keeping the amphibian



THE AMPHIBIOUS AUTOMOBILE READY TO ENTER THE WATER.

in bad weather it is safer to keep the amphibian tail seaward, the new model has a two-cycle engine which runs backward or forward with equal ease. The engine used is a twenty-horsepower Fox motor, and this new model has been named "Sea Fox." The "Sea Fox" measures thirty feet from bow to the tip of its ten-foot tail; it is six feet broad, three feet deep, and its centerboard drops six feet into the water.



AS A MOTOR-BOAT IN DEEP WATER.

The uses to which this new invention may be put are varied. At beach resorts people may embark at the very door of cottage or hotel, drive along the beach, enjoy a ride on the water, and

return in the same manner. Fishermen may find both convenience and safety in its use. Their catch may be taken direct to market, and they need no longer fear being caught out at sea in a bad storm, since the amphibian can make a landing in any weather. But perhaps its most important use may be in the life-saving service. Be-

cause it is able to ride the highest surf without danger of overturning, it may lessen the peril of the brave crews of our life-saving stations, and because it is able to go at once into the water without the delay and difficulty of launching, it may render more prompt and efficient aid to vessels wrecked along our coast.

THE MAKING OF OUR GASLIGHT

THE very beginning of the gaslight goes back millions of years, to the days when there were still growing the great forests that fell and were buried and turned into coal. In that coal the sunshine of ages is stored, and the chemist has taught the gas-makers to bring out the light and heat of the sunshine and send it through pipes into our homes. We call it gas, but it is just as proper to say, "Turn on the sunshine," as it is to say, "Turn on the gas."

If an American boy should say to his father, "Please cut off all the gas in the house, I am afraid I shall be blown up by it!" we should consider him very foolish, for every child knows that if we are careful with gas there is no danger. But in the first half of the last century people knew so little about gas that the Queen of England told the Duke of Wellington to cut off the gas and stop up all the pipes in Windsor Castle because she was afraid of it.

What happens when we light the gas? When we turn on the cock and the gas comes rushing out of the burner, we put a lighted match or other small flame to it and the gas is lighted. Nothing could be easier than this; and as soon as a child is old enough to be trusted with matches and can reach the fixture, he is allowed to light the gas. It is all very simple now, but a great deal of trouble has been taken to make the gas ready and to bring it along the pipes into our houses.

It is such a wonderful story that to get right at the beginning of it we should have to tell how coal was made. See if you can find out about that, then we can go on to see what we do with coal, which has in it a great number of things that clever men have learned to get out of it. Let us suppose we are at a gas-works. In comes the coal; men put it into things called retorts. These are big, hollow tubes made of iron or of clay, fixed into a great furnace with a fire underneath them. The retorts are filled with coal, and the fierce fires underneath bake the coal as if it were a pie. Then a strange thing happens. The

coal, being so very hot, partly melts, or dissolves—as a piece of sugar dissolves in a cup of tea, or as snow dissolves in the sun. To understand what happens, we may try a little trick.

Take a long clay pipe. Fill the bowl of it with tiny pieces of bright coal. Then fix some clay tightly into the top of the bowl, covering up the coal. Now ask your father to put the bowl of the pipe into the bright red cinders of the fire, leaving the stem of the pipe sticking out toward you. You have made a retort on a very small scale. If you watch for a moment or two you will see a thin stream of smoke come out of the stem of the pipe. That is gas. If a lighted match is put to it, the thin stream of smoke will light.

That is what happens in the large retorts. The gas escapes from the coal and goes out through a big pipe at the top of the retort. It rushes along a lot of other pipes. It goes through water and lime, along more pipes, and through other things which make it clear and pure, until at last it is ready to give a bright flame without smell or smoke.

How this happens will be clear by a brief lesson in chemistry. The gas that burns, the chemist tells us, is largely hydrogen. Hydrogen forms a large part of ordinary coal. In fact, the coal that was put into the retort consisted of carbon, hydrogen, and oxygen, with a few other substances. We put the coal into the retort and heated it so that it would be decomposed, and the hydrogen would be freed from the carbon, which would remain as coke, a spongy substance that the gas companies, after they have removed it from the retorts, sometimes sell as fuel. It makes a warm and even fire in fireplace or furnace.

Hydrogen gas is found elsewhere than in coal. It is around us everywhere in water, and one of the first lessons of chemistry is that water is composed of hydrogen and oxygen, the latter a gas that is also in the air we breathe, and is very necessary for our life and health. This is one of the early experiments that we see in the school chemical laboratory when the professor passes a

current of electricity through a dish of water in which he has placed two little glass tubes filled with water and standing upright but bottom up. He has connected two wires that dip into the water under the tubes with the electric-light fixture, and soon bubbles are formed and gases take the place of the water in the two test-tubes. If a test is made we find that one contains hydrogen and the other oxygen. Now if we can get the hydrogen from water we do not have to go down in the earth for coal and heat it to destructive distillation, as the chemist calls it, in the gas-retort. This idea occurred to a man who made a great quantity of hydrogen gas to fill large balloons which would rise high up in the air. It was Thaddeus S. C. Lowe who, in the American Civil War, went up from within the Northern army lines and observed the movements of the Southern soldiers almost as well as if he had been a bird flying over their camps. After Professor Lowe had given up military ballooning for works of peace, it occurred to him that he could separate the hydrogen from the oxygen in water that was everywhere in abundance. It would not do to use electricity as does the professor in the chemical laboratory, for if you have electricity at your command why not use electric light? No, it must be a process even cheaper than distilling the coal in the retort. Now Professor Lowe recalled the fact that great heat would also separate the hydrogen and the oxygen of water, so he made apparatus in which he could send a jet of steam over a hot fire of glowing coal. Now, steam is water, only in a different condition, just as ice is frozen water, so when the steam passed over the white-hot coal the hydrogen was released from the oxygen. But here we have another wonder of chemistry. The hot coal, which, as we have seen, was largely carbon, unites with this oxygen, and we have a gas formed of carbon and oxygen. This gas then takes more carbon from the glowing coal, and we have another gas which the chemist calls carbon monoxid. Now this, like the hydrogen, is combustible, so from the water-gas apparatus we obtain a mixture of two combustible gases. But here we have a new condition to meet. While these gases burn, they do not give a luminous flame, so after all we have to go down in the earth again for assistance from Nature. In treating petroleum to make ordinary lamp-oil, certain oils are produced that give a very luminous flame, and if we add these oils in the form of vapors to our water-gas we are able to send it through the pipes just as we did with the coal-gas. This water-gas was much cheaper to manufacture, and, when enriched with naphtha, it was found to give a brighter light.

Besides, the gas-works did not need to be built so large, or employ so many men. Soon water-gas became general for most of the large American cities, leaving coal-gas for the smaller works. In Europe coal-gas still is used a great deal.

The gas, whether it is coal-gas or water-gas, at last reaches the gasometer, a large round tank standing high in the air, like an ugly iron balloon. At the bottom of it is a well of water. The gas, being lighter than air, floats in the air. When it rushes into the gasometer, it forces its way up. The gasometer, though it looks so heavy, is so nicely balanced by the water and air that it rises with the gas until it is full. As the gas leaves the gasometer to come to our houses, the gasometer sinks slowly down again into the water. The gasometer is always gently pressing down upon the gas, and this helps to force the gas into the pipes.

These pipes are made of iron, and are placed deep down in the ground. They are very strong and carefully fitted, end to end, or else the gas would leak out and be wasted. The pipes have to be laid so that they can be easily examined to let out any water which may get in. The pipes go in all directions. Some go under water on river-bottoms or in tunnels; some are laid along railway bridges; some go through tunnels. Wherever there are street gas-lamps, we may know that somewhere under our feet the big gas-pipes have been laid. When the pipe reaches the house, smaller pipes must be laid, so that the gas can reach all the rooms. They are laid under the floors or inside the walls, and chandeliers or brackets are suspended from ceilings or side walls. Then all we have to do is to turn the cock and light the gas, and the darkest room becomes as bright as day.

We know that many children are afraid of the dark, and that every one likes a bright light so that there shall be no dark corners in our rooms; then we can see to read without harming our eyes. But when we have lighted a large number of gaslights we find that the air in our rooms is being consumed. The professor of chemistry will tell you that the oxygen in the air we breathe is necessary when anything burns, and that if it is taken by the gas flame it is exhausted, so that the people in the room are liable to headache. It was soon found, too, that gas-bills became large when much gas was used. Therefore, when the electric light was ready many people used it, as it did not use up the air of the room, and was a pleasant, bright light. But the electric light depended on the coal just as did the gas. The coal was burned under the boiler of a steam-engine, the water was turned into steam, which

made the engine run, and the engine turned the dynamo that supplied the electricity.

The gas-man did not give up when electricity began to be used. He added more naphtha to his gas to enrich it, and then he turned to the chemist. There was a distinguished German man of science who was studying substances known as rare earths—so rare indeed that they were not used for practical purposes but merely as scientific curiosities and in mineral collections. Doctor Carl F. A. von Welsbach noticed that these substances when heated became very luminous, glowing much more brightly than the wire of platinum upon which he put small quantities into his gas-flame to heat them white-hot, just as we might heat a lady's hat-pin in a gaslight. Then it occurred to him to use a cotton thread instead of the platinum wire and dip it into a solution of a salt of the rare earth, especially one called thoria. Of course, the cotton soon burned away, but a little basket remained which glowed very brilliantly. Being a very thorough man, Dr. Welsbach tried all the rare elements he had in his collection. He used minerals so rare that their names are most unfamiliar—zirconia, lanthania, and yttria—but they were not as good as thoria, which gave the brightest mantle and one with the longest life. This he patented in 1886. Next he added to thoria oxide of cerium, and found that this was an improvement, and soon we had the familiar incandescent or Welsbach gaslight. Here was a chance to get even with electricity, for the new light was cheaper and quite as bright. In 1875 an argand gas-burner gave a little over three candles' light for every cubic foot of gas; now more than ten times that amount of illumination is secured. Only new burners are needed, and if everybody used incandescent gaslights the gas companies would not have to enrich their gas

with naphtha. So, instead of gas giving place to electricity, we find that it is more used; for people, becoming used to the bright light of the incandescent bulbs, look for the same in Welsbach mantles, and find that they can get sufficient illumination without large gas-bills.

The same gas will heat the oven in which your dinner is cooked, or will broil your steak. It will drive an engine, just as steam does, and we have explosive engines for houses and factories like those used in automobiles. It will warm the greenhouse, and keep plants snug and cozy in the winter. It will make the water warm for your bath in the morning, and it will burn brightly all night in the lamps in the streets.

We must not play with gas, nor be careless, for we shall find it as dangerous as the Queen of England once thought it was. If we were to let it escape into the room, and then struck a light, it would blow the house up. Many a serious accident is caused by looking for a gas-leak with a lighted candle, especially in a cellar. If when we were in a close room we turned on the cock without lighting the gas, it would slowly kill us.

Now that we see what a wonderful thing gas really is, we need not wonder that a queen was afraid of it. There were many great men living in those days who knew very little more about it than she did. One of them said: "If you try to light London Bridge with gas everybody will be poisoned." Even Sir Humphry Davy, who was a very great chemist and a clever man, said: "Before you can safely use a gasometer, you will have to put on the gasometer a weight as big as Primrose Hill to keep the gasometer down." And he thought that the men who said that they could light the streets of London by gas were dreaming. But we know that these men were right and the great Sir Humphry Davy was wrong.

HOW A LIGHTHOUSE IS BUILT

ONE of the most wonderful things to think of is the way in which men have been able to make light when darkness creeps over the world. A great city lit up at night is a beautiful sight to look upon. Have you thought, when you have been in the dark, how difficult it must be for the sailor to find his way at sea when the moon is not shining and the stars have shut their eyes? We cannot put lamps everywhere in the sea as we do in the streets, yet there are dangerous rocks which would wreck a ship if the captain did not see them. On these rocks, then, and at dangerous

parts of the sea-coasts, men build lighthouses, with lanterns that throw a great light over the dark water, to help the sailor to find his way and keep his ship out of danger.

One dark night, many years ago, a ship was sailing on the sea near the coast of Greece. It was so dark that the captain could not see how to guide the vessel, so he made up his mind to stay until morning brought the light to let him see where to steer.

Soon after he had stopped the vessel, some one cried out: "I see a light!" There, far away, was

a tiny light, like a dim, distant star, twinkling in the blackness that hung over the sea.

"I know now where we are," said the captain. "We are near the big rocks of Cape Matapan. A kind old man lives there all by himself. When he hears the noise made by the engines of a ship, he knows that the ship is in danger of running on the rocks. So he lights his little lamp and waves it, just as he has done now, to show us where we are."

And now, having got to know where he was, the captain was able to start the ship again, and steer away safely.

There are many places where ships are in danger. There are hidden rocks; there are great cliffs where they may run ashore at night; there are great banks of sand just beneath the water where they may stick fast. The ships have to be guarded from these dangers. But we cannot have men running down to the water's edge with lamps wherever these dangers are. Instead of that, we build great lighthouses, whose light can be seen far over the sea.

These lighthouses are built in all sorts of places. Some are on the land; some are built out in the sea on rocks, over which the waves are often sweeping. Others are built on sand. These are hard to build, because, before the foundations can be laid, great piles of timber have to be driven down into the soft sand, so as to make a firm base for the lighthouse.

Men who build lighthouses are so brave and clever that if they could only keep to their work without being interfered with by the sea they would soon get the work done. But they cannot work for long, because the angry sea will not let them. Once, the men who built a lighthouse could only work for thirty hours in a year! Sometimes a lighthouse takes years to build.

The great Bell Rock lighthouse in Scotland is built on a rock exposed in the cold, rough sea. When the men began to work, only two at a time could be there. There was not room for more. The first thing they had to do was to scrape the thick layers of seaweed off the rock, then drill holes in the rock, so that they could drive in iron rods, and build round these a strong iron platform. This was really only the beginning of the work.

Every few minutes the waves came dashing over the rock, and the poor men had to lie flat down, grip the seaweed with all their might, and hold their breath until the water had passed over them. Then they would get up again and go on with their work. When the first Eddystone lighthouse, in England, was built it took the men four years to make twelve holes in the rock, so that

they might build the foundations on which the lighthouse could stand.

When they have got as far as this the work really begins. Heavy tools, machinery, and all sorts of stone and other materials, have to be brought to the spot in ships or boats, and it is hard and dangerous work to get them into the right positions.

One of the most wonderful ways of building a lighthouse was that in which the new lighthouse at Beachy Head, on the south coast of England, was built. There was a lighthouse there on the top of the cliffs, but it was placed too high. Sailors at sea in a fog could not see the light, so a new lighthouse was built at the foot of the cliff, but right in the sea. First of all they had to make a great hole in the chalk under the sea; then, when the tide was low, they built round this hole a big, thick wall, called a dam. They made the dam so big that they could work inside the ring until the tide was very high; then they had to get out.

The men next built in the sea a high platform, made of iron, like a pier at the seaside, only shorter, and very strong. This was their workshop, where they put their things when the tide came in. But up on the top of the cliff they had another workshop, and all sorts of things with which to build.

To bring these things from the top of the cliff down to the sea they made a railway in the air. They had great wire ropes fastened on the top of the cliff and on the platform in the sea, then fastened once more in a bed of concrete set in the sea. These ropes reached from the cliff down to the platform in the sea, and were so strong that a weight of over a hundred tons would not have broken them. Two of these wire ropes made a sort of railway for trucks to glide down, and two more made another railway to carry up other trucks. Then, when one truck carried down its load, it caused the other truck to come up on the other ropes.

In these trucks the men went down to their work, and each truck could carry twelve men out over the sea nearly three hundred yards through the air.

Down this railway they carried all the machinery and all the great blocks of granite that they needed. Some of the blocks of granite weighed as much as four cartloads of coal each, but they were carried down without accident of any kind.

Each piece of granite had come from Cornwall, and had been cut so that it would exactly fit into the next. To make quite sure that they fitted properly, they were all built up on land, then num-

bered and taken to pieces, and put together again in the sea in exactly the same order.

This lighthouse is forty-eight feet thick at the bottom, and for a long way up it is a solid granite rock. Then come the eight rooms built inside the lighthouse, one on top of another. First, there is the door by which the men enter and receive their goods. Above these are storerooms and rooms to live and sleep in; then the room where the men trim the lamps and, on top of all, the room in which the great lantern is kept. The lantern throws its light across the sea and turns round and round, so that it can be seen from any side.

One may say that the whole system of modern coast-lighting grew up within about the lifetime of a man, for modern lights attempt far more than our forefathers ever thought of accomplishing. In the old days, it was enough if a few of the most dangerous points were lighted, but our idea to-day is to make all parts of the coast of every civilized land safe for mariners. The sailor is provided with books and lists showing every light he is to go near, and by changing from one to another he can pick his way along coasts, in and out of harbors, or from shore to shore of bays.

This makes modern lighting so well worth while, so important to merchants, that there is nothing too expensive to lend aid where many ships pass. All forms of lighting are tried, oil, acetylene, electricity, and that one kept in each station where it proves best.

So the building of lighthouses varies according to localities. Wise engineers study each place and decide according to the roughness of the sea, the kind of foundation, the height to which a light must be raised, the number of men necessary to attend to lighting, and so on, how much money can be rightly used, and then draw their plans for lighthouses of stone, of steel framework or tubes, of brick, of plates of metal, according to what will best stand the waves and protect the keepers.

The question of lighting is no longer one of simply caring for the great oil-lamp. Now, learned men all over the world are studying the making of lenses, and the constructing of clever

machinery, so as to give motion to the lights and cause them to signal passing ships.

Thus it has come about that modern lighthouses show all the improvements in modern building. Instead of heavy stone structures, locked together by shaping, are light-looking, but really strong, steel structures, through which the waves dash without much resistance.

The lamp above may now be incandescent or electric, and the lens that sends its rays out is constructed of hundreds upon hundreds of prisms of glass. All the rays may be strengthened by being reflected in curiously shaped mirrors.

Besides lighthouses, light-ships are stationed by governments—especially by our own—at points where light-ships are more useful than lighthouses would be, as over a shifting shallow. They are anchored, can outride storms, and the keepers live in them for weeks or months at a time, keeping alight the lanterns at their mast-heads. Where lesser lights are needed, beacons or buoys are placed to mark channels or courses to be followed in entering harbors.

Where fog and snow prevent lights from being safe guides, sound-signals—bells, gongs, guns, whistles, and sirens—are operated by the lighthouse-keepers; and these, by changing the signals given, serve, like the lights, to tell sailors what stations they are nearing.

The most recent method of guarding coasts, and a method that can be used where either a light or a sound is needed, is that of sending out wireless signals by electricity. Inventors to-day are working upon the problem of making these signals show whence they come, and a day is looked forward to when a mariner can sit sheltered within his vessel and read over the wireless receiver signals that will tell him just what he could learn if he were out on the deck of a steamship bridge, studying lights and trying to make out fog-signals. Mariners call these newest stations "blind lighthouses."

In our own times, all nations that call themselves civilized feel impelled to work together for the safety of commerce, and the system of lighthouses and of coast-guarding, as practised to-day, is one of the signs that a time will come when the world will be considered one people.





THE OLD AND THE NEW.

LONG, LONG AGO, MAN SPREAD HIS SAILS, THE WILDEST SEAS TO DARE—
BUT NOW HE SCORNS THE RAGING MAIN AND RIDES UPON THE AIR!

THE LIGHTS THAT GUIDE IN THE NIGHT

BY LIEUTENANT JOHN M. ELLICOTT, U. S. N.

WHEN ships are sailing upon the ocean the lights of heaven are their guides. Even in the dark ages, when the compass and sextant were unknown instruments, the seemingly motionless pole-star hung like a beacon-light in the northern heavens, and the rising and setting of the sun and stars distinguished the east from the west. When, however, ships come near the land the lights of heaven are not sufficient safely to guide them. Rocks lie in their paths unseen in the night; reefs and shoals spread under the water; while unsuspected currents sweep the frail craft all blindly upon these dangers.

Nevertheless, ships were sailed along dangerous coasts for centuries before a plain system of marking dangerous places was invented. The early mariners were bold and reckless rovers, more than half pirates, who seldom owned a rood of the coasts along which they sailed, and could not have established lights and landmarks on them had they cared to do so. The rude beginning, then, of a system of lighthouses was when the merchants with whom the reckless mariners traded in those dark ages built beacons near the harbor mouths to guide the ships into port by day, and lighted fires for their guidance at night. As such a harbor-guide had to be a sure landmark in the daytime and a light by night, it soon took on a settled shape—a tower on which could be built a fire; and such a tower was usually built of stone.

This method of guiding ships into the ports which they sought was scarcely established before human wickedness used it as a means for their destruction. Bands of robbers, or, as they came to be called, "wreckers," would hide themselves somewhere near the haven sought by a richly laden vessel, and after overpowering the fire-keepers would extinguish the beacon-fire on the night on which the ship was expected. Then they would light another fire near some treacherous reef. The mariner, sailing boldly toward the false light, would dash his vessel to destruction on the reef, whereupon the robber band would plunder the wreck and make off with the booty.

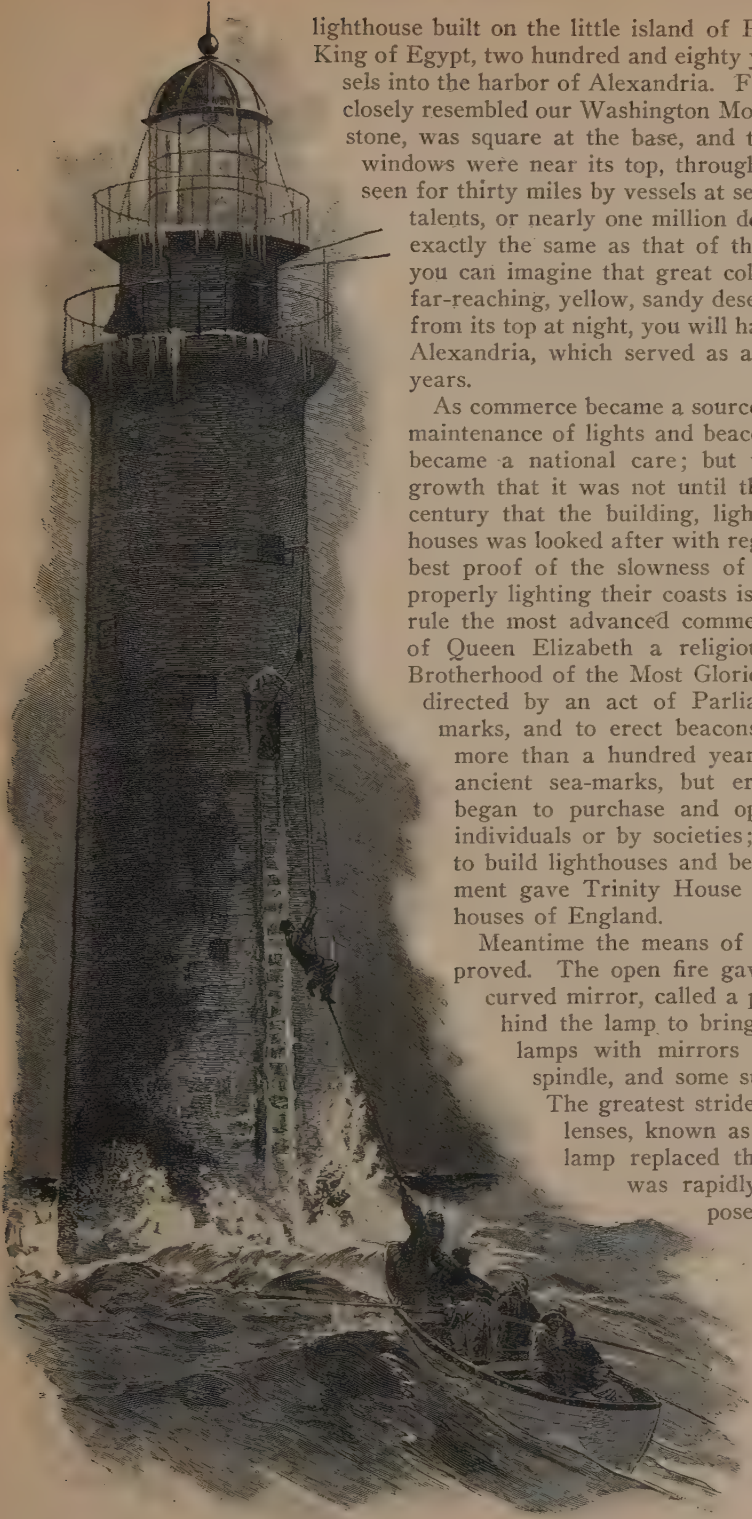
The Mediterranean Sea was the great cradle of commerce, and some of the ancient beacon-towers at the entrance to its harbors stood intact for centuries. The giant statue known as the Colossus, at Rhodes, is supposed to have been used as a beacon and lighthouse—the spread of the legs of that great figure of Apollo indicating

the harbor entrance by day, while a fire burned in the palm of his uplifted colossal hand at night. Although the account of the Colossus is only a matter of guesswork, it is historically true that in



A SCREW-PILE OCEAN LIGHTHOUSE ON
FOWEY ROCK, FLORIDA.

those ages of ignorant heedlessness of the need of beacons a lighthouse was built so grand in proportions, so enduring in character, that it became known as one of the Seven Wonders of the World, and outlived all the others, save the Pyramids, by centuries, and in some ways has never been excelled by any similar structure in modern times, unless it be by our mammoth marble monument to Washington. This was the



lighthouse built on the little island of Pharos by Ptolemy Philadelphus, King of Egypt, two hundred and eighty years before Christ, to guide vessels into the harbor of Alexandria. From all descriptions, it must have closely resembled our Washington Monument; for it was built of white stone, was square at the base, and tapered toward the apex. Open windows were near its top, through which the fire within could be seen for thirty miles by vessels at sea. To build it cost eight hundred talents, or nearly one million dollars; and its height was almost exactly the same as that of the Washington Monument; so if you can imagine that great column standing solitary on a low, far-reaching, yellow, sandy desert shore, with a fitful fire flaring from its top at night, you will have clearly in mind the Pharos at Alexandria, which served as a lighthouse for sixteen hundred years.

As commerce became a source of great revenue to nations, the maintenance of lights and beacons for the protection of vessels became a national care; but this was of so very gradual a growth that it was not until the beginning of the seventeenth century that the building, lighting, and maintaining of lighthouses was looked after with regularity by all governments. The best proof of the slowness of nations to see the necessity of properly lighting their coasts is afforded by Great Britain, as a rule the most advanced commercial nation. During the reign of Queen Elizabeth a religious brotherhood known as "the Brotherhood of the Most Glorious and Undivided Trinity" was directed by an act of Parliament to preserve ancient sea-marks, and to erect beacons and "signs of the sea." For more than a hundred years this brotherhood kept up the ancient sea-marks, but erected nothing new; then they began to purchase and operate lights owned by private individuals or by societies; and still later they commenced to build lighthouses and beacons. Finally, in 1856, Parliament gave Trinity House the entire control of the lighthouses of England.

Meantime the means of lighting was being steadily improved. The open fire gave place to the oil-lamp; then a curved mirror, called a parabolic mirror, was placed behind the lamp to bring the rays together; next, many lamps with mirrors were grouped about a central spindle, and some such lights are still in operation.

The greatest stride came when an arrangement of lenses, known as the Fresnel lens, in front of a lamp replaced the mirror behind it. This lens was rapidly improved for lighthouse purposes, until now a cylindrical glass house surrounds the lamp-flame. This house has lens-shaped walls which bend all the rays to form a horizontal zone of strong light which pierces the darkness to a great distance.

The rapid increase in the number of lighthouses has made it necessary to have some means of telling one from another, or, as it is

termed, of giving to each light its "characteristic." Coloring the glass made the light dimmer, but as red comes most nearly to white light in brightness, some lights have red lenses. The latest and



SECTION OF
A FRESNEL
LENS.

best plan, however, is to set upright prisms at intervals in a circular framework around the lens, and to revolve this frame by clockwork. Thus the light is made to flash every time a prism passes between it and an observer. By changing the number and places of the prisms, or the speed of the clockwork, the flashes for any one light can be made to occur at intervals of so many seconds for that light. Putting in red prisms gives still other changes. Thus each light has its "characteristic," and this is written

down in signs on the charts, and fully stated in the light-lists carried by vessels. Thus, on a chart you may note that the light you want to sight is marked "F. W., v. W. Fl., 10-sec.," which means that it is "fixed white varied by white flashes every ten seconds." When a light is sighted you see if those are its characteristics; and, if so, you have found the right one.

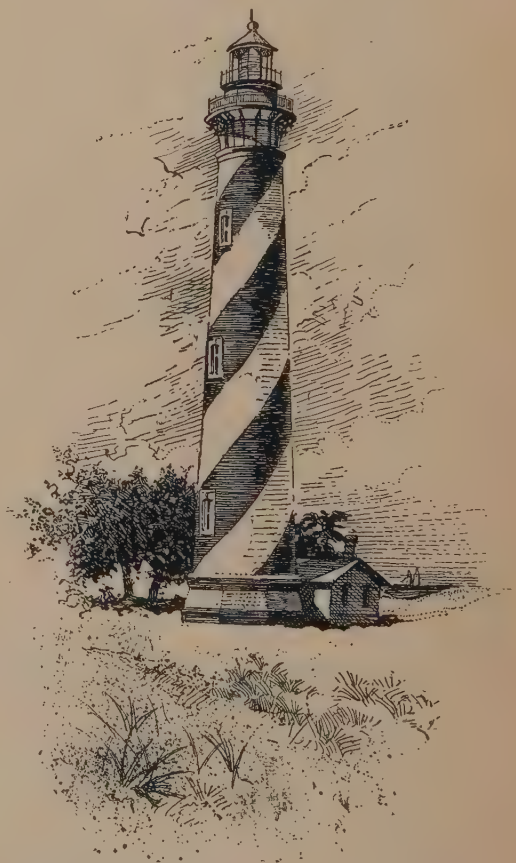
Another scheme is used on the coasts of France, in addition to those I have told you. It is a means for swinging a vertical beam of light across the sky at regular times. Thus the whereabouts of a light can be discovered by the appearance of its beam long before the light itself shows above the horizon.

Lighthouse buildings are variously painted so that they will have a "characteristic" by day. Thus some towers are red, some black, some white and black in horizontal or vertical stripes, some checkered, and some painted in spiral bands like those on the typical barber's pole, as shown on this page.

One seldom thinks, when he watches the brightly cheering and safely guiding light of a lighthouse, what ceaseless watching and patient heroism it takes to keep the light burning year in and year out through all weathers. Generally there is for each light only a keeper with two assistants, and often the keeper is assisted only by his wife, sons, or daughters. Even the most comfortably situated lighthouses are generally on lonely headlands, with no human dwelling near. Others are on outlying rocks, or islands swept by the sea, and wholly cut off from the land except in fair weather. There are even a few which, built upon sunken reefs, seem to rise from the very bed of the ocean, and against which storm-driven seas break with shocks which shake

them to their foundations. Such are the Eddystone Lighthouse, off the coast of England at the entrance to the English Channel, and our own Minot's Ledge Light, near the entrance to Boston Harbor. These two are the most isolated and exposed lighthouses in the world. They were built at the utmost peril to human life. Each was swept away by storms after completion, and had to be rebuilt.

The first lighthouse on Minot's Ledge was built in 1848. It was an octagonal tower resting on the tops of eight wrought-iron piles eight inches in diameter and sixty feet high, with their bases sunk five feet in the rock. These piles were braced together in many ways; and, as they offered less surface to the waves than a solid structure, this lighthouse was considered by all



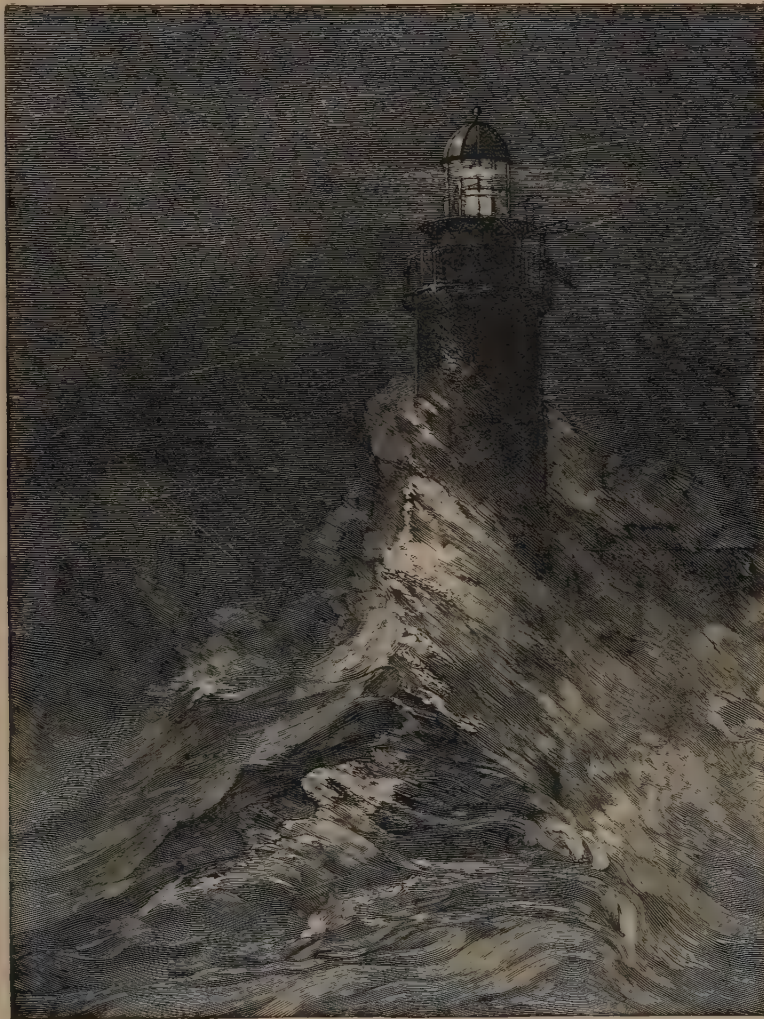
THE LIGHTHOUSE AT ST. AUGUSTINE, FLORIDA.

authorities upon the subject to be exceptionally strong.

Its great test came in April, 1851. On the 14th of that month, two keepers being in the lighthouse, an easterly gale set in, steadily increasing

in force. People on shore, and no doubt the keepers themselves, watched the heavy seas sweep harmlessly through the network of piles beneath the house, and feared no harm. On the 15th, however, the wind and sea had greatly increased, and the waves were flung higher and higher toward that tower in the air. Yet, all thought

seemed to bend to the shock of the waves. At four o'clock that afternoon an ominous proof of the fury of the waves on Minot's Ledge reached the shore—a platform which had been built between the piles only seven feet below the floor of the keeper's room. The raging seas, then, were leaping fifty feet in the air. Would they

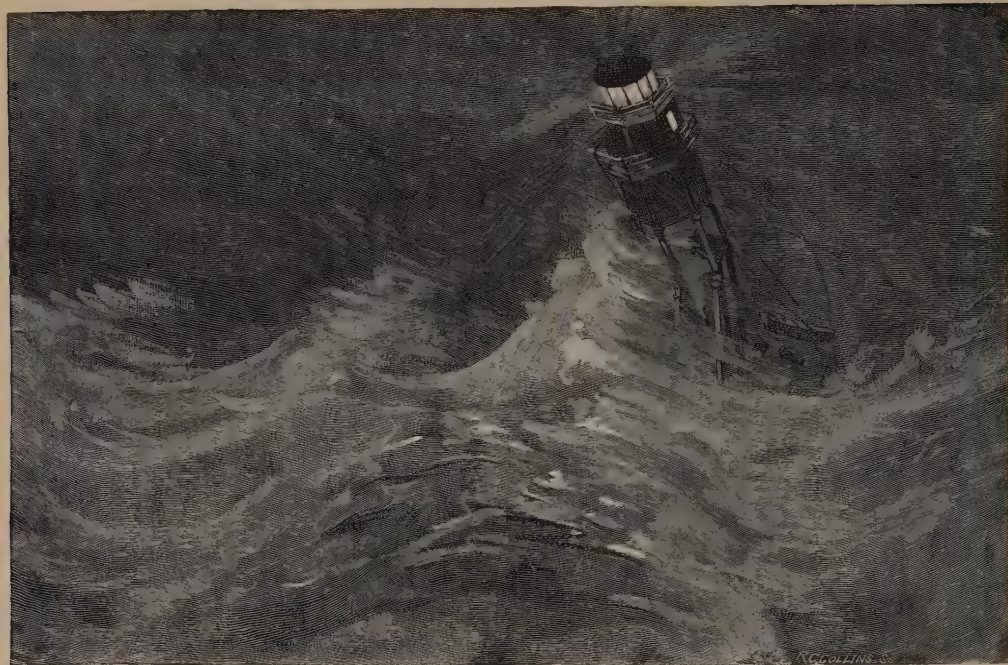


IN A NORTHEASTER.

they surely could not reach sixty feet above the ledge!

That night was one of keen anxiety, for the gale still increased; and all through that dreadful driving storm and darkness, the faithful keepers were at their posts, for the light burned brightly. On Wednesday, the 16th, the gale had become a hurricane; and when at times the tower could be seen through the mists and sea-drift, it

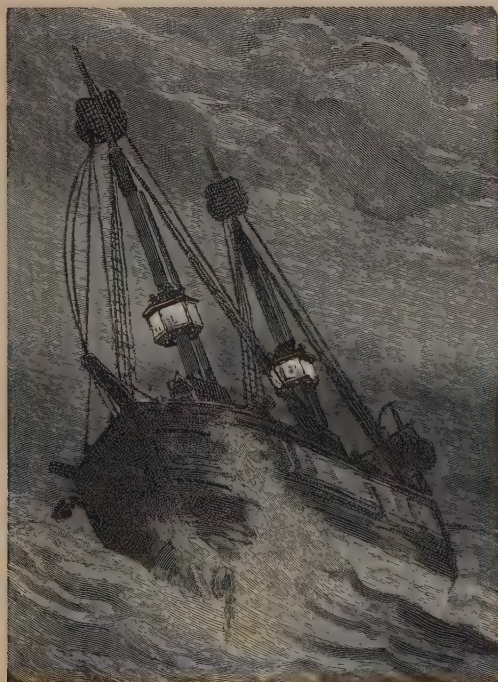
reach ten feet higher?—for if so the house and the keepers were doomed. Nevertheless, when darkness set in the light shone out as brilliantly as ever; but the gale seemed, if possible, then to increase. What agony those two men must have suffered! How that dreadful abode must have swayed in the irresistible hurricane, and trembled at each crashing sea! The poor unfortunates must have known that if those seas, leaping always



THE WRECK OF THE FIRST MINOT'S LEDGE LIGHTHOUSE.

Engraved by R. C. Collins.

higher and higher, ever reached their house, it would be flung down into the ocean, and they would be buried with it beneath the waves.



THE SOUTH SHOAL LIGHT-SHIP, OFF NANTUCKET.

To those hopeless, terrified watchers the entombing sea came at last. At one o'clock in the morning the lighthouse bell was heard by those on shore to give a mournful clang, and the light was extinguished. It was the funeral knell of two patient heroes.

Next day there remained on the rock only eight jagged iron stumps.

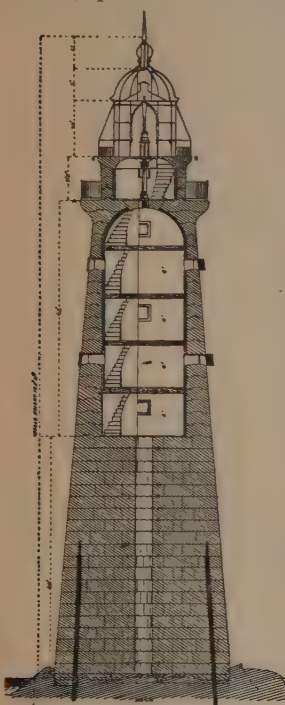
During this same gale another lighthouse, twenty-five miles out at sea on that New England coast, was sore beset. It was on a barren rock of considerable area, known as Matinicus Rock; and besides the tower there were sub-



ON A QUIET DAY.

stantial stone buildings for the keeper's family and for storing supplies. The keeper had gone away for provisions, leaving an invalid wife and four daughters in the station. The eldest daugh-

ter, a girl of seventeen, was in charge of the light. During the first day's gale the seas began to sweep entirely over the rocks, washing away everything movable, and flooding the lower rooms of the dwelling. The roar of the surf and the wind was so great that the poor women could not hear one another's voices. At this stage of the storm the young girl remembered her chickens, and determined to save them. Taking a large basket, she stood at an upper window watching the sea. When there came a quiet spell she rushed out of the dwelling, dashed ankle-deep through the sea-water draining from the rocks, dragged the poor drenched hens from the perches where they had taken refuge from the waves, placed them in the basket, and dashed



SECTION OF THE PRESENT
MINOT'S LEDGE LIGHT.

back into the house again, with all saved—all but one, which was out of her reach, and for which she could not linger; for hardly had she secured the door and retreated again to the upper floor, when a most terrific sea broke over the rocks, sweeping away every house except the stone dwelling and its light-tower. As the storm grew worse, the dwelling had to be abandoned, and all lived in the light-tower for three days and nights, during which the little light-keeper never lost her nerve, but kept the light burning as regularly as clockwork.

Lighthouse-keepers do not seem to feel their lonely life. I once spent a week on Scotland Light-ship, near the entrance to New York harbor. The assistant keeper was in charge, and he was nearly stone-deaf. He had not been ashore for three months, and even a newspaper came to him only by chance from time to time, when a pilot-boat stopped by on her way out of the harbor. From sunrise until nine o'clock at night he did little else but sit on a hatchway smoking an old pipe and gazing reflectively at the great harbor receiving and dismissing its thousands of vessels. One day he asked me to use my influence to get

him transferred to Cape Cod. I asked him why he wished the change.

"Well," said he, very seriously, "I want a



Sketch of the
screw at the end
of the pile.

SCREW-PILE RIVER LIGHTHOUSE.

quieter station; it's too lively here; I want to be where there is less going on!"

Light-ships take the place of lighthouses on shoals which are too much exposed, or where sands are too shifting to allow lighthouses to be built on them. These vessels are very securely moored, and newer ones have auxiliary steam-power, so that if they should break adrift in a storm they could steam into the nearest port for shelter, or lie to until the gale abated. Their lights and lenses surround one or both of their masts, and in the daytime are lowered down into a little house at the foot of the mast. At night the lamps are lighted, and the lights hoisted up



THE FOG-BELL.

again to the mastheads. On some shoals, usually in rivers and bays, where the water is not too deep and the sea is never violent, lighthouses are built on a trestlework supported by iron piles screwed into the sand.

The entire lighthouse system of the United States is in charge of a board consisting of two army engineer officers and two naval officers of high rank, and two civilians. This board is under the Treasury Department, and the Secretary of the Treasury is *ex-officio* president. Its meetings are held in the Treasury Building in Washington. The country is divided into sixteen lighthouse

districts, as follows: first to sixth districts, Atlantic coast; seventh and eighth districts, Gulf coast; ninth to eleventh districts, the Great Lakes; twelfth and thirteenth districts, Pacific coast; and the remaining three districts include the Ohio, Mississippi, Missouri, and Red rivers. Each district is in charge of a naval officer who is termed an inspector. The headquarters of the third district, on Staten Island, is the principal depot of supplies. Lamps and lanterns are made there; all oil is tested there; and all lighting apparatus is set up and worked there before being sent to its destination.



MINOT'S LEDGE AFTER THE STORM OF 1851.

THE STORY OF THE MICROSCOPE

HALF the wonders of the world are never seen by human beings. We learn very slowly. It took us millions of years to find out about steam and electricity. The use of gas for lighting was not discovered until years and years after men had seen that it would burn and light dark places. Radium, and the wonderful Röntgen rays, which enable us to photograph the inside of the body, have been discovered since young readers of this story were born. Not until Galileo turned his telescope up to the stars had men really seen the heavens and their marvels.

Wonderful as is the telescope, the microscope is to most of us more wonderful still. It does not make distant objects seem near. The object to be examined has to be placed quite close to the glass of the microscope, but it makes those objects seem so large that there are few secrets of nature which we cannot examine.

For thousands of years men were on the way toward making the grand discovery of the microscope, but they stopped short of full success.

When Sir Henry Layard was digging in the rubbish that covered the great palace in Nimrud, a city near Nineveh, he found in the ruins a lens of rock-crystal—that is, a lens of natural glass—which had been used as a magnifying-glass when people inhabited that Assyrian city thousands of years ago.

How could they have discovered the use of the magnifying-glass all those ages ago? Probably it was because they learned that if a tiny object, placed on a flat surface, were covered by a drop of clear water, the little object would be made to appear large. They would not understand that a transparent object which has its surface arched outward, like an egg, alters the direction of the rays of light traveling through it. This alteration of the direction of the rays is called refraction. The effect of this is to gather together the rays of light coming from all quarters, to focus them on the object under the lens, and to make that object appear as a very large, clear picture to the eye. The ancients would find that glass, shaped like a

drop of water, would do the same thing, and in engraving their seals and gems they worked so finely that it seems certain that they used magnifying devices of some sort. In fact, we know that spectacles were used by the ancients.

At different times in history other men made just the same sort of discovery. Men made magnifying-glasses by melting many threads of glass together into bubbles, and by blowing glass balls and filling them with water. Seneca, the old Roman philosopher, tells us about hollow spheres of glass used for this purpose. Polished gems also were so used. The word lens tells us what men thought of the things they used. They called the glass a lens because it reminded them of the shape of a lentil-seed. Spectacles are one of the forms of these glasses for making things appear larger and nearer, and the spectacle-makers of Europe we have to thank for the compound microscope and the telescope.

The first man to make a study of microscopes was Antonius van Leeuwenhoek, a poor Dutch clerk, who was born in 1632 and lived till 1723. He ground and polished lenses which magnified things he looked at. His was the best simple or one-lens microscope—as now we term a single magnifying lens mounted on a stand—of his day. His work was very important. In 1628 Harvey had given the world his explanation of the circulation of the blood in our bodies. That was the greatest discovery ever made by a surgeon up to that time, but scarcely anybody knew what it meant, and many people did not believe it. But Leeuwenhoek, with his microscope, was able to examine the blood in the veins and actually to see it flowing along—the first man who had ever done so. He was able to say that Malpighi, the Italian anatomist, was right in his theory that the blood passed through fine passages or capillaries. He showed that blood was made up of corpuscles which for man were circular, but for frogs and fishes were oval in shape.

Leeuwenhoek was most industrious in his study of the structure of animals and plants, more and more of which was revealed to him as he worked with his microscope. He found out how the flea and other insects grew from eggs, and how weevils in the grain came from grubs, and how small insect pests, rather than some of the larger and more visible insects, did great damage to fruit-trees. In fact, he investigated all the minute forms of life that occurred to him, and in 1683 he was able to report to the Royal Society of London that he had encountered new evidences of life which we now know as bacteria.

Harvey would have given all he possessed to see proved what he had shown in his diagrams to

the Royal College of Physicians, but he was in his grave before Leeuwenhoek made his microscope. Although Leeuwenhoek did so much wonderful work, he could not go beyond the powers of the microscope he made. It remained for other men, like Dr. Wollaston and Sir David Brewster, in England, to make big improvements. They had great trouble with the lenses, so much so that Brewster said that we should have to use diamonds for the lenses. What was sought in the way of improvement was to increase the power of the microscope to magnify and to make the object examined clear and sharp as well as large, and with its colors preserved, not all jumbled together.

The man who finally achieved this was Joseph Jackson Lister, the father of the late Lord Lister, the great English surgeon and father of anti-septic surgery. Lister was not poor, but he was practically a self-educated boy. He suffered from short sight in one eye. When he sat at the window looking through an air-bubble formed in the glass, he saw that the bubble made the things beyond the window clear to his weak eye. This set him thinking about the use of lenses for the eyes, and when quite a little boy he managed to get a telescope—the only boy in the school to have one. But as he had to work hard, it was not till 1824, when he was nearly forty years of age, that he had time for bettering the microscope.

He employed a man to make lenses for him, but soon Lister had to take up the work himself and to make his own. He discovered that previous ways of making and arranging the lenses had been wrong. He made new lenses and arranged them in a different way. Then some great lens-makers in Germany began to make microscopes of fine quality, and a number of university professors contributed their knowledge of optics to make these instruments most useful to all men of science. The eyepiece we look through; the little lenses of the objective which do the high-power magnification; the stage on which we put the slide prepared with the object we are to study—all these have been improved so that now we can examine plants and animals and rocks, all in a condition far, far beyond that visible to the naked eye. Thus, in the field of bacteriology, where the living organisms are so small that 1500 would be needed to extend across the head of an ordinary pin, the lenses must magnify at least 1000 times in diameter.

But even before this stage had been reached, great men were using the microscope to learn the truths of nature. Louis Pasteur, the great French chemist, was studying fermentation and the cause of disease in plants, animals, and men,

and while he could not see the individual organisms, yet he was able to study the results of their activity, and to see how the tissue of the body changes when they are at work in it.

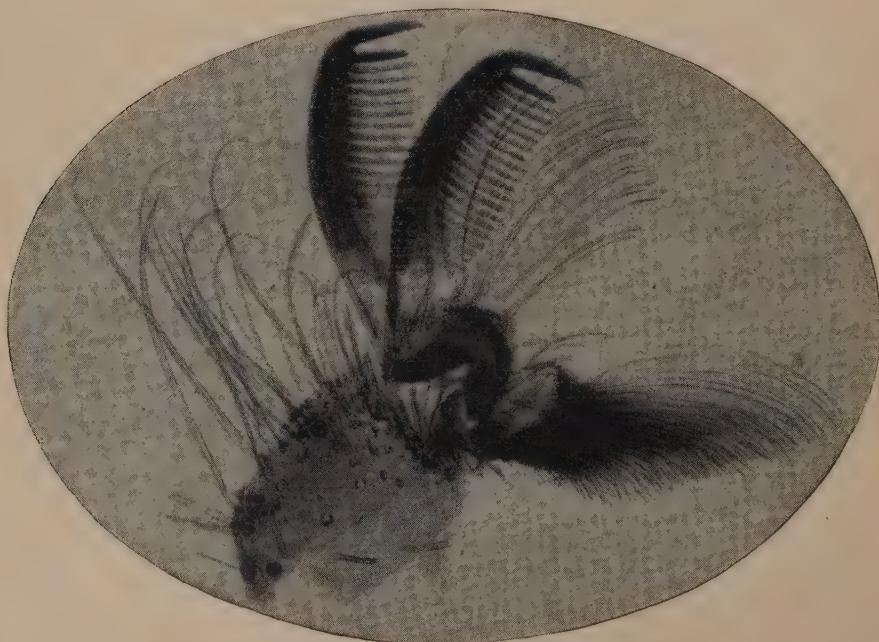
By the aid of the microscope we can see a world of living things in a drop of pond-water; we can make a grain of sand look like a great crystal with the light shining through it; we can see living animals in the human blood fighting out their battles before our eyes; we can see a tiny piece of rose-petal becoming a marvelous web of silver cells, all filled with fluid; we can see a claw like the claw of a lion on a caterpillar.

But most of all it enables us to study forms of minute life that are connected with our sickness and health. To-day the physician examines a drop of our blood, pricked out with a needle, to ascertain the presence of small forms of animal life that indicate disease, such as malaria. The familiar microbes or germs, as we may have them, are all detected by the great powers of this wonderful instrument. Let us suppose that a child has sore throat. The physician calls, takes a specimen from the throat of the patient, and sends it to the Board of Health, where a culture is made in broth, gelatin, bouillon, or material derived from animal blood obtained at the slaughter-house—some substance which, with gentle heat, is favorable for the rapid growth of these germs. After sufficient time has elapsed,

the test-tube containing the culture is removed from the warm temperature of the incubator, the progress of the development is arrested, and the germs are killed and made harmless. Then the material is placed on a slide, stained, perhaps, to render it more visible (for certain germs take a color which is refused by the surrounding mediums), and under high powers the physician, or his assistant, or the microscopist of the Board of Health, carefully examines the slide. "No diphtheria," reports the microscopist, for the germs have failed to develop under artificial conditions that were best suited for their growth, and then the physician knows that his patient has only a sore throat, which will be cured in a few days. Thus the father and mother are greatly relieved, for they fear no serious result.

Again, perhaps the microscope shows the characteristic formation of the diphtheria germs. Then the physician must use the antitoxin which many experiments with the microscope have developed. Or a disease may be one supposed to be carried by the mosquito, and it is necessary to examine the blood of that insect and find whether it really is the medium of transmission of germs.

The microscope reveals to us wonders that Shakespeare never saw; marvels that the greatest kings of the past could not have seen had they offered their crowns to see them.



FOOT OF THE EMERALD-SPIDER UNDER THE MICROSCOPE.

THE SEVEN WONDERS OF THE WORLD

BY AUGUSTA HUIELL SEAMAN

THERE is something unusual, something peculiar, so it has always been claimed, about the number *seven*. From earliest days it was held to be a magic number, a mystic number, though no one has ever been able to explain just why it was thought to be so.

How familiar we are with its constant use in history, astronomy, the Bible, and elsewhere! Rome was built on her seven hills, Greece boasted her Seven Sages, astronomy began with the seven stars in the Great Bear and the seven Pleiades. Time was measured by the week of seven days, and man's life by its seven ages. The Bible abounds, from Genesis to Revelation, with the suggestive number—the seven days of the world's creation, the seven golden candlesticks, the seven stars, the seven churches of Asia. And who does not remember the constant use of the same number in our well-loved fairy tales! Not one but many a story is centered around seven brothers or sisters, or hinges upon the performing of some task seven times or during seven years.

It is not surprising, then, to learn that the great wonders of the world were counted as "seven." The Greeks were the first to think of forming such a list, far back in the time when the civilized world was just beginning to be proud of the works it had accomplished. About one hundred years before Christ we hear of this catalogue for the first time. Later it was adopted by the Romans. From them it was handed down to the Middle Ages, and so in the course of time reached our own day, practically unchanged from its earliest mention by one Antipater of Sidon. According to the age of the "wonders," the list reads as follows:

The Pyramids of Egypt,
The Hanging Gardens of Babylon,
The Statue of Zeus at Olympia,
The Temple of Diana at Ephesus,
The Mausoleum at Halicarnassus,
The Colossus of Rhodes,
The Pharos of Alexandria.

Let us take first *The Pyramids of Egypt*, the oldest structures in the world, and the only one

of the Seven Wonders that remains to be seen to-day.

So old are the Pyramids that to reckon their age would be almost an impossibility. We can obtain some faint idea of their years, however, from the fact that when Moses looked upon them in the days of the children of Israel's captivity in Egypt, they were already considered monuments of the forgotten past.

Why were they built, and by whom? That is a question which has excited the curiosity of scholars from the time of Aristotle and Herodotus down to this day. But after careful search it is now generally believed that they were erected by several of Egypt's ancient kings as *tombs* where their royal bodies might rest, safe from the destroying power of the muddy Nile and from the shifting desert sands.

There are many pyramids in Egypt, but those to which we refer are the three situated at the edge of the Sahara Desert near Memphis. The oldest and largest is called the Pyramid of Cheops, named, it is supposed, after the ancient king who caused it to be built. It is 482 feet high, and each side at the base measures 756 feet. These figures may perhaps mean little to us, but put in another form we shall obtain a better idea of the dimensions. If we started at one corner of the structure to go around the base, we should have walked half a mile before reaching the same corner once more. Again, we have all read or heard of that imposing building, the Church of Saint Peter's, at Rome. It has been calculated that if the Pyramid of Cheops were hollow, Saint Peter's could be placed within it like a clock under a glass shade, and still leave 52 feet of extra space at the top.

The Pyramids are built of massive rough-hewn blocks of stone—built solid with only a few narrow passageways and chambers within. It has been calculated that were Cheops to be dismantled and a wall built of its stones, that wall would be long enough to encircle the entire country of France!

The sides of the Pyramids are terraced like flights of steps, each step about four feet high, and by means of them travelers may ascend to

the very summits. But the sides were not always so. Originally they were filled in with prism-shaped blocks, making the entire surface perfectly smooth. So they were in the days when Herodotus, the great historian, wrote of them. But in the fourteenth century A.D. these prismatic blocks had already begun to be torn away, probably for other building purposes.

Within these Pyramids have been discovered, in recent years, the chambers where the bodies of Egypt's early kings were doubtless placed. But the mummies themselves must have been removed centuries ago, and all traces of them lost beyond recovery.

So they stand on the edge of the desert, these marvelous first "wonders of the world," guarding still the secret of their 5000 years of existence. And we look upon them to-day with no less of awe than did the Greek or Roman traveler of old, who crossed the Mediterranean, often at great peril, to view for himself the most remarkable structures ever raised by the hand of man.

The next "wonder" that we find on the list reads, *The Hanging Gardens of Babylon*.

Nebuchadnezzar was king over the great Babylonian Empire. Babylon, then the most important city in the world, was his capital, and to this city he had brought his queen, Amytis, the daughter of a Median king. Babylon lay in the midst of a wide, flat plain, and was a busy commercial city. Poor Amytis began to long for the forests and mountains of Media whence she had come, and most naturally she made her longing known to the King, her husband.

Now Nebuchadnezzar had several excellent reasons for being prompt to please Amytis, and keep her happy and content. In the first place, he was probably fond of her. But perhaps even stronger than this was the fact that her father had helped him to overthrow the powerful city of Nineveh, and make Babylon the metropolis of the world. Across the mountains, however, lay that hated rival of Babylon, the kingdom of Persia. It was only by maintaining a friendship with the Medes that Babylon could hope to keep her position as mistress of the world. When the Medes and Persians should join forces against her, farewell to her greatness. Therefore was Nebuchadnezzar extremely anxious to keep in the good graces of his Median queen—and her father! This is how he did it.

He caused to be erected on the bank of the river Euphrates, which flowed through the city, a monstrous structure in the form of four great terraces, each 100 feet wide, and each 20 feet above the other. The structure was composed of layers of arches and tunnels, on the tops of which

were planted trees, shrubs, and flowering plants, till the whole looked like a great mountain of verdure. Through the pile was sunk a shaft by which water from the river was pumped up, to keep this artificial garden continually moist and fresh. It is supposed that the whole was finished about 596 B.C.

Here Amytis could wander to her heart's content, and imagine herself back in her childhood's home. Doubtless she was delighted that Nebuchadnezzar should grant her whim at such tremendous expenditure of money and labor, but history does not inform us of that. One thing, however, is certain. The Hanging Gardens became renowned as a world-wide "wonder." The captive Jews whom Nebuchadnezzar forced to leave Jerusalem and dwell in Babylon doubtless saw and marveled at this blossoming mountain of verdure in what was otherwise a flat and ugly plain. Small wonder is it that Nebuchadnezzar, surveying them in the midst of the mighty city, congratulated himself in these words:

"Is this not great Babylon which I have builded?" But Providence had a lesson in humility in store for Nebuchadnezzar. A strange madness suddenly seized him, and for a long while he ate grass like the ox, and conducted himself generally as a beast of the field. When finally reason returned to him, he became, no doubt, a sadder and a wiser king!

In the course of time, after a reign of 40 years, Nebuchadnezzar died and was buried with his fathers. Babylon and her wonderful Hanging Gardens continued to flourish, but not for long. The very event that Nebuchadnezzar had so feared, occurred not long after his death. In the reign of Belshazzar, the city was captured by the Medes and Persians, and from that date passed continually from hand to hand, subject of Persians, Greeks, and Parthians.

What remains to-day of these wonderful Hanging Gardens? Only a heap of ruins scarcely distinguishable from the general desolation, just within the north wall of the city. The traces of the shaft that carried water to the top alone indicate what this particular mound may have been. Nothing now to remind us of that marvelous, cunningly devised imitation of a forest-covered mountain, save its place in history as one of the "seven wonders of the world."

Egypt has furnished us with the first "wonder" on the list, and before the end shall provide another. Babylon boasted the second. Greece gives us the third in *The Statue of Zeus at Olympia*.

As we review these wonders we notice that they are of two classes, either tremendous struc-

tures or enormous statues. In the day when this list was made, "bigness" formed almost the only qualification for being a "wonder." The statue of Zeus, chief of the Greek gods, has, however, one other characteristic to recommend it. It was the work of that great sculptor Phidias, whose masterpieces adorned every building of note in the land.

Pericles was ruler of Greece in those days (480 B.C.), and Phidias was his right-hand man in the adorning and redecorating of Athens. One of his most famous creations, the colossal gold-and-ivory statue of Athene in the Parthenon, had begun to excite the wonder and admiration of all Greece. But right upon the heels of this wonder came the thought: "Athene is not our highest divinity, yet she possesses the finest statue. This will never do—Zeus, the father of all the gods, will be angry! Zeus also must have a statue, larger, if anything, than that of Athene!"

Now the temple of Zeus was at Olympia. That city lost no time in commissioning Phidias to set to work, and furnished him with all the necessary means and material. The result was a statue of pure gold and ivory, 40 feet in height, the chief masterpiece of the great sculptor. The statue, a seated figure, was placed in the temple. So majestic were its proportions that the worshipers used to fear lest the god might sometime rise from his throne and in so doing lift the roof from the temple! But their fears were groundless. Zeus never annoyed them by an action so ill-judged!

The body of the statue was of solid ivory, and the mantle and sandals of richly carved gold and enamel. The chair or throne was of ivory and ebony, decorated with precious stones. The waving tresses were also of pure gold, surmounted by a crown of green-enameled olive-leaves. But the face of calm, benignant majesty was such as only Phidias could have fashioned.

Nothing remains to-day of either the temple or the statue, and only from engravings of the statue on small ancient Greek coins can we guess at its form or likeness. Both the statue and the temple perished in the burning of the city by Theodosius the Great. Apart from its size, as a marvelous piece of artistic work it rightly claims a place as one of the world's "seven wonders." Even that wise old stoic philosopher Epictetus deemed those unfortunate who died without beholding it.

We travel to Ephesus for the fourth of the wonders, where was found *The Temple of Diana or Artemis*.

This we perceive to be another massive structure which, by the way, is the only one of the

list dedicated to the worship of a divinity. The goddess referred to was known to the Romans as Diana, and to the Greeks as Artemis. The city of Ephesus, which was not Greek originally, but was at the time much under the influence of Greek culture and government, boasted Diana as its patron goddess. To her the city had erected a wonderful temple in the seventh century B.C. During 400 years this stood, the admiration and envy of all the world, and then a strange thing happened.

In the year 356 B.C. lived in Ephesus a youth by the name of Herostratus. This youth had never done the least thing to distinguish himself, yet in spite of that he yearned for fame. After much thought on the subject he was suddenly struck with a brilliant idea, and he realized that it was in his power to do something which the world would never forget. One night he set fire to the temple of Diana, and in a few hours the magnificent building was a heap of ruins. Herostratus attained his wish. Even an English poet has said of him:

The aspiring youth that fired the Ephesian dome
Outlives in fame the pious fool that rais'd it.

At any rate, if Herostratus thought that was the end of the Temple of Diana, he was much mistaken. It was but the beginning of greater things. So wide-spread was the grief throughout the Grecian world at this disaster that many cities sent rich gifts in money to the Ephesians, and a new temple was at once begun on a far grander scale than the other. Then indeed it became a "wonder of the world." From accounts of its dimensions we know that it must have exceeded the cathedral of Milan in size, and was far ampler than St. Paul's in London.

But the Temple of Diana has long crumbled to dust. In 262 A.D. the Goths destroyed the building, and in the thirteenth century the Turks used some of its stones in erecting their Mosque of Selim. In 1871 some English excavators found amid the ruins of this mosque all that remains of one of the world's seven wonders.

The fifth of our list somewhat resembles the first, in that it is a *tomb*. It is known as *The Mausoleum at Halicarnassus*. There is, however, this difference. The Egyptian monarchs raised the Pyramids as secure resting-places for their bodies, and paid little heed to beauty of form or ornament. The Mausoleum, on the contrary, was not only a tomb, but a monument of beauty as well.

King Mausolus and his wife Artemisia were monarchs of the kingdom of Caria in Asia Minor,

whose chief city was Halicarnassus. In order both to beautify his capital and gratify his own sense of importance, Mausolus decided to build a magnificent monumental tomb for himself and his wife, a structure that should last down through the ages and keep fresh in memory his greatness. The work was duly begun, but Mausolus died before it was half done, about 351 B.C. His wife saw that the building was continued, but even she died before its completion. The monument, however, promised to be so beautiful that the work was finished by the subjects of the dead rulers.

The structure was square in shape, two stories in height, and surmounted by a solid pyramid, on the apex of which was a carved four-horse chariot containing figures of the King and Queen. The whole was about 140 feet high. In using a pyramid as part of the construction, they probably borrowed the old Egyptian idea of having a tomb in pyramidal form. Exquisite statues and columns ornamented the lower portion of the building. The whole was the work of Greek artists, so Greece can boast a share in two of the world's wonders.

The Mausoleum was so called after the name of King Mausolus, and to this day monumental tombs are often called mausoleums. For fifteen centuries that "wonder" stood undisturbed, till there came a day when, careless of its beauty, it was thought that so much good building material might be used for other purposes. The work of destruction began at the top, and the stones of the pyramid went to build a fortification for the Knights of St. John.

Thirteen blocks of carving now in the British Museum are all that remain to-day of this wonderfully beautiful building, the monument which King Mausolus vainly hoped would last to the end of time!

The sixth wonder is again a statue of imposing height, and is known as *The Colossus of Rhodes*.

The city of Rhodes, on an island of the same name, was in the third century B.C. one of the most important on the Mediterranean. It was to the civilization of that day what Paris is to us, a center of art, culture, commerce, and wealth, and was esteemed by the Romans as the fairest city in the world. It contained a university, to which went some of the Roman emperors and even Cicero. Here also the first Greek grammar was written.

The patron divinity of this city happened to be Apollo, the sun-god, because it was believed that he had raised the town from the waves of the sea. It finally occurred to the Rhodians that it was time they erected to him some suitable monu-

ment. What should it be? Other cities boasted wonderful temples and altars. Rhodes felt that she would like to do something a little more original, and finally hit upon a plan. The city was on an island 15 miles from the mainland, and possessed an excellent harbor. The Rhodians decided to erect a colossal statue of Apollo on the shore of the harbor, that all who came into their port, or passed by in ships, might recognize at a glance their favorite divinity.

To Chares, a sculptor of the city, was given this task, and it took him twelve years to complete it. The statue was made of brass, and stood with each foot on a marble pedestal. Its height was 105 feet, and so great were its proportions that a man could not span one of its thumbs with his two arms. Our own Statue of Liberty in New York harbor to-day far exceeds this ancient "wonder." It is 45 feet higher, and proportionately larger in every way.

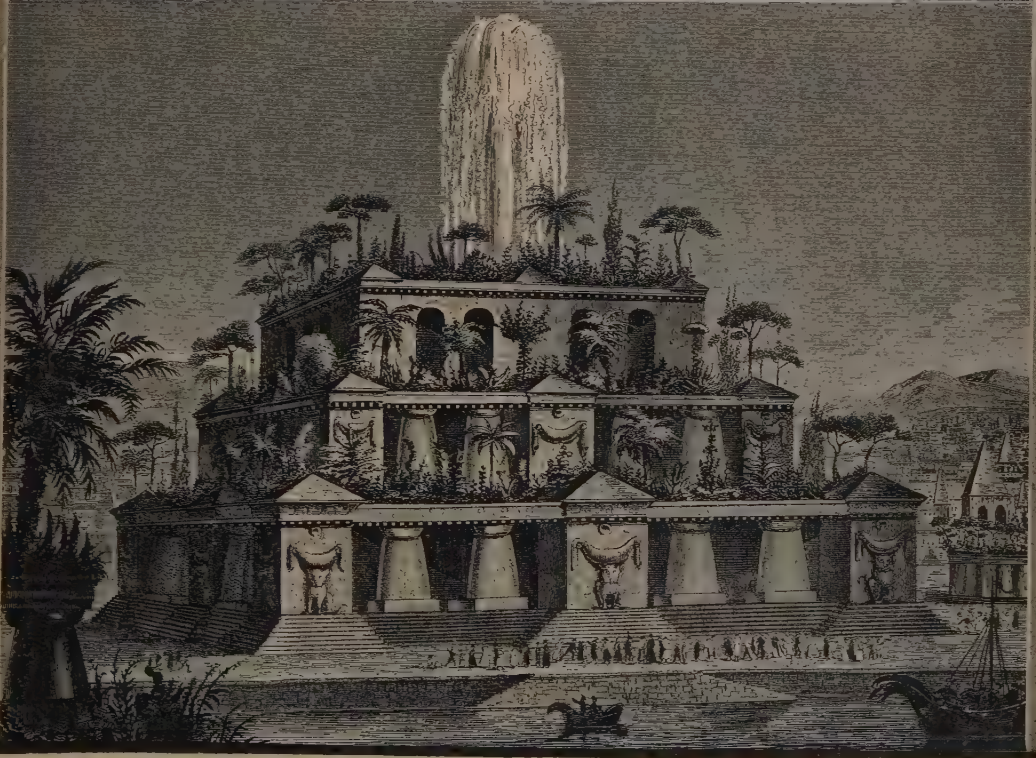
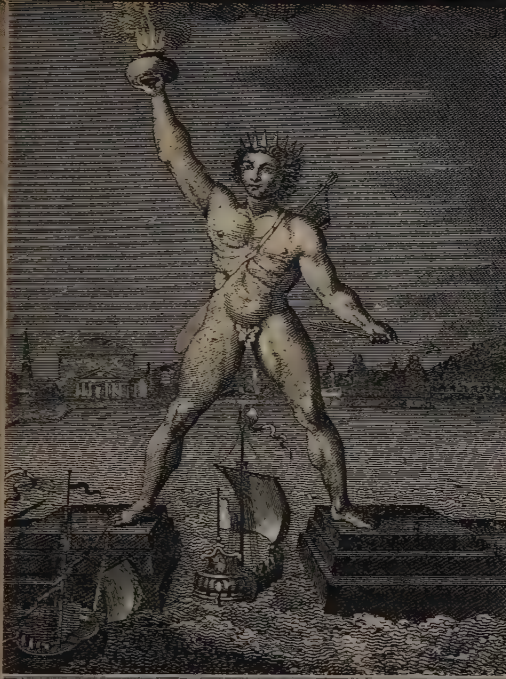
The Colossus of Rhodes, as it came to be called, was unfortunately not destined for a long existence in its proper position. It stood by the harbor, the pride of its city, for 56 years, and then a great earthquake in 227 B.C. tore it from its pedestal. For nine centuries longer it lay in all its fallen grandeur, still as much of a wonder, almost, as when it stood erect by the blue waters of the harbor.

Then, alas! came its ignominious end. Rhodes fell into the hands of the Saracen Turks, who saw no reason why the shore should longer be littered with this useless, ruined piece of sculpture. So they sold it to a Jewish junk-merchant, who was obliged to employ 900 camels to carry the pieces away. Thus vanished another of the "seven wonders"!

The last of our list of wonders is perhaps the most remarkable of all. It is known as *The Pharos of Alexandria*.

Soon after the death of Alexander the Great, when the city of Alexandria in Egypt was at the height of its prosperity, the King, Ptolemy Soter, was moved to carry out a very useful and original idea. He proposed to construct a huge lighthouse at the edge of the city's harbor, which should be a guiding beacon for miles on the perilous Mediterranean. He arranged with an architect, one Sostratus of Cnidus, to commence the construction, but he himself died long before its completion, and his successor, Ptolemy Philadelphus, reigned during the greater part of the time it took to accomplish this tremendous piece of work.

The lighthouse was erected on the little island of Pharos, connected with the mainland by a stone causeway. Hence the beacon was called a "pharos," and to-day a part of the same word is



COLOSSUS OF RHODES

PHAROS (OR LIGHTHOUSE) AT ALEXANDRIA

HANGING GARDENS OF BABYLON

These are taken from quaint old prints, and show how fancifully engravers once represented such things, with little attempt at real archæological accuracy.

recognizable in "phare" and "faro," the French and Spanish terms meaning "lighthouse." The structure was the largest of its kind in the world, was built on a square foundation, and rose to the height—so it was said—of 400 feet. In the open space at the top great fires of wood were kept constantly burning, and it was declared that the light could be seen forty miles out at sea.

A curious legend about it tells how King Ptolemy Soter wished his name engraved upon it, that all future generations might credit him with the work. But the wily Sostratus considered that *he*, as the architect and builder, should have this honor, and to that end he resorted to a trick. In the hard stones of the base he carved his own name, then plastered it over with cement and engraved the King's title on the less lasting ma-

terial. So it came about in the following centuries, when the years and the ocean-storms had done their work, that not "Ptolemy Soter," but "Sostratus of Cnidus" was seen to be the name engraved on the white stones of the world's first lighthouse.

For 1600 years the Pharos nobly fulfilled its purpose, and many a galley-slave, straining at the oar in the stormy Mediterranean night, blessed the gods for his preservation, as he caught the flash from its shining fires. To-day not a trace of it remains, nor is it known when or by what means it disappeared. Some think that an earthquake probably caused its destruction. However that may be, its purpose did not perish with it, for it became the inspiration and type by which future lighthouses were modeled.

SOME OTHER WONDERS OF THE WORLD

BY MARY V. WORSTELL

THE "Seven Wonders" of ancient times are not the only wonders of our world. They are rivaled by many achievements of other times and peoples. Thus, seven wonders of later ages were the Colosseum of Rome, the Catacombs of Alexandria, the Great Wall of China, Stonehenge in England, the Leaning Tower of Pisa, the Porcelain Tower of Nankin, and the Mosque of St. Sophia in Constantinople.

All these were the works of man, and we may well regard them with admiration when we consider the skill, patience, and ingenuity which produced them when mechanical devices, such as we have to-day, were so few.

While all these "wonders" are in lands beyond the sea, yet our own country is rich in wonders of another kind—wonders not made by man. There is the enormous Canyon of the Colorado River, flowing through Arizona, where it has cut a huge channel for itself—a gorge 200 miles long and from 8 to 12 miles across; a gorge so deep that when we stand on the steep brink we can look down for fully a mile. But this is not like a deep and empty trough; it is filled with beautifully colored formations of every possible shape—butes, mountains, towers, pillars, and even peninsulas that stretch far out into the big chasm. There is no similar formation in the whole wide world.

Then there is the stately Yosemite Valley in California, hemmed in by wonderful walls of cool gray granite, and over these walls dash streams,

even rivers, that make great ribbons of light and foam before they go singing down the lovely valley between banks of giant trees and shrubs and flowers.

The Yellowstone Park, larger than the State of Rhode Island, contains more enchanting wonders—geysers, boiling springs, a rainbow canyon, etc.—than ever can be enumerated.

Niagara Falls and its turbulent gorge are far more accessible than those just mentioned, and so have a greater number of visitors. The Natural Bridge of Virginia, though it attracts fewer visitors than other wonders, is not only of great interest in itself, it has a special claim to our regard since it is associated with the great name of George Washington. The Mammoth Cave of Kentucky, in which one may travel for miles, both on foot and by boat, through lovely halls and chambered archways, pillared with glistening stalactites, is a wonder worth while journeying far to see.

There are still countless other marvels in our great country, but in order to keep ever to the mystical number, seven, we will mention only one more—the big trees of California. There are ten groves of these tree-giants, and in these groves are hundreds of trees whose circumferences are from 40 to 90 feet, while in height many of them equal the Statue of Liberty in the harbor of our greatest city. Should we not be proud of a country so richly endowed with marvels as our own?

THE PLEASURE OF HOUSEWORK

BY MARY V. WORSTELL

Not long ago a story was printed which told of a certain lady who found herself unexpectedly called upon to do her own housework. She had heard others fret and fume over such work, but she was somewhat cleverer than the fault-finders. Instead of grumbling and fretting, she wisely made up her mind to see only the pleasant side—to *make* a pleasant side if necessary.

"A pleasant side to housework?" you ask in surprise. Yes, indeed! There is not only one pleasant side, there are many.

The lady in question was something of an artist, and when she really began to work in her kitchen she saw that it was not an attractive place. A very little time and expense quite transformed it. A pretty curtain cut off an ugly corner; shelves of bare boards were covered with white enameled cloth; some growing flowers were placed in the window, and a few attractive tiles were substituted for crude advertising cards and calendars stuck here and there by a careless cook. And, lo! the homely old kitchen was changed into a place of beauty, while housework and cookery in this bright, cheery room became a real pleasure and no drudgery at all.

Now it is not possible for young people to undertake changes and improvements in kitchens, but no kitchen that is absolutely clean and in order is unsightly. Nowadays many kitchens are very small, and this has certainly one advantage—when everything is within reach, it is easier to keep all in order.

WASHING DISHES

WHEN there are dishes to be washed, let us set about our task in the right way. Let us first gather up the larger dishes, such as platters and vegetable dishes; next, the plates (never more than two at a time), on which rest the knives and forks. Then, on a little tray, collect salts and peppers, butter-dishes, etc. Now the table should be "crumbed," using the usual little tray and brush, or perhaps a napkin folded in a square,

and brushing the crumbs on a plate. The dull knife often used instead of a brush plays havoc with a table-cloth, causing it to wear out quickly. Many well-served tables are "crumbed" with the brush or napkin from preference.

When it comes to washing dishes, we have a fair field for feminine and even masculine skill, since to do this properly is almost an art, and to do it with a skilful economy of time and labor calls for a good bit of "calculation."

First of all, whatever food is left over should be cared for. Meat should be placed on as small a plate or platter as will hold it, that it may occupy little space in the refrigerator or "cooler." Butter should be set in a cool place as soon as possible lest it become soft. Left-over vegetables should also be put in small dishes, and they, as well as the meat, should be set aside till cold, that they may take no heat into the refrigerator.

Now that the platter and vegetable-dishes are empty, we put them near our dish-pan and turn our attention to the plates. These should be scraped with a knife or a stray crust of bread till no food adheres. Then pile the plates neatly and place them beside the platter. Next treat smaller dishes in a similar way till all are arranged in an orderly fashion. Put knives, forks, and spoons in some deep vessel, such as a wide-mouthed pitcher, and cover them with very hot water. If a good supply of hot water comes from a faucet, set the pitcher where the hot water will run in and out for a few minutes, and we shall find that these small articles are washed with almost no labor. But, a word of warning!—knives with ivory handles should not be placed in hot water. It cracks the ivory.

The glasses—the last things to be removed from the table—are the first things to be washed. Empty any water that may be in them, and plunge them in soapy water, not very hot; rinse them quickly in a smaller pan of hot water, and a few brisk rubs will make them bright and shining. Next wash any delicate cups and saucers by themselves, being careful not to use very hot

water, which will often crack a thin cup or plate. Nothing is daintier on a table than pretty, delicate cups and saucers. It is worth while to give them the special care they demand.

Now turn to the knives, forks, and spoons, and a very few minutes will suffice to rub and dry them. The small dishes come next. Have some hot suds for these and for the plates as well. Let the dishes remain in the hot suds a few minutes, then, with a cloth or dish-mop, remove any substance that may still adhere. The dishes may then be rinsed by placing in a second pan of clean water. This second, smaller pan should contain water as hot as the hand can comfortably bear—not scalding water.

Many hardware and department stores sell racks for draining dishes. They fold up something like a camp-chair, and when unfolded present many narrow openings in which plates may be placed. When one must wash dishes quite alone, a rack of this kind is a real help, because the water drains off at once, and the dishes almost dry themselves. As soon as they are dried, glasses, silver, cups, and plates should be arranged in orderly piles preparatory to putting them in their places.

Last of all come vegetable-dishes and platter, which, like the plates, must be washed in hot suds and then in clear water. When all the glass, silver, and china have been put away, we turn to the pots and kettles—the “black artillery,” as certain college girls call them. Let us confess frankly that it is difficult to become enthusiastic over this part of the work. But just whisper to yourself, “I’ll do this quicker and better than ever before!” and see how quickly the whole task is done. Do not enter on this work of the home with sullenness or with a look of utter despair. Go about it in a cheery way, and if you are fortunate enough to have some one to help you, just exchange a few jokes, and turn the whole dreaded task into a merry half-hour.

SETTING THE TABLE

THE one necessary quality in an attractive table is neatness. No matter how fine and beautiful the china, no matter how expensive the linen, unless the table-cloth be clean the quality of the furnishings will mean nothing. So, first and foremost, let the table-cloth be spotless.

If possible, add a pretty centerpiece, a round or square piece of linen, embroidered or hem-stitched, perhaps bordered with crocheted edging or linen lace. This gives a delightful touch of daintiness. If a few flowers in a vase can

grace the centerpiece, you are fortunate indeed. Nothing adds such charm to a table (or to the home at large) as flowers. There is an old Eastern proverb which says: “Hast thou two loaves of bread? Sell one of them and buy flowers!” Almost any country roadside or field will furnish us with a lovely bouquet if we are careful not to mix kind and color with a reckless hand. Pink and white clovers are so common that we almost forget they are beautiful. Suppose we pick a handful of them, adding some clover-leaves. Is it not charming?

A pretty change from a vase of flowers is to place a little basket in the center of the table, in it setting some dish, tumbler, or bowl that will fit. Then fill with flowers. Occasionally a low, wide-mouthed preserve-jar may be placed in a bowl of copper or brass. And in a metal bowl nothing is so charming as green, either green leaves or ferns. In the country there is an infinite variety of beautiful leaves from which to choose. And again, an early spring flower growing in a dainty vase or flower-pot is lovely enough to satisfy the most exacting. Avoid, if possible, having a high mass of flowers on the dining-table, for it is not pleasant to crane one’s neck in order to see who is sitting opposite.

In setting the table, place the knife at the right-hand side with the sharp edge of the blade turned toward the fork at the left-hand side. The handles of both knife and fork should be about an inch from the edge of the table. If soup is to be part of the dinner, place a soup-spoon beside the knife; if salad is to be served as a course by itself, place two forks at the left; if pie or pudding is to be the dessert, put still another fork at the left, or a spoon beside the soup-spoon. By having all these small utensils in place before the dinner begins, the serving is greatly simplified.

Napkins, whether in rings or not, should be placed at the left of the plate. Put the glass for water at the right side, a little to the front of the knife.

To the thoughtful little girl who wishes to be a real help in the home, many other small services will suggest themselves in connection with the dining-room. She will see that the chairs and sideboard are dusted, and that crumbs, scattered on the floor, perhaps, by some younger child, are not allowed to remain to offend the sight. Possibly she will also place on the sideboard whatever plates may be needed during dinner, and so make easier the serving of it. Nowadays, when good “help” is hard to find, and when the burden of the housework often falls on Mother, think what a pleasure it would be to her to find that her little daughter had thoughtfully set the table

for breakfast the night before, and in this way had lightened the first work of the day.

CARING FOR HER ROOM

MANY a girl does not think her room "pretty" unless it is crowded with knickknacks. Well, so long as "girls will be girls," they will set great store by these small possessions. A number of little photographs may serve to recall a summer's fun, and a few college banners may bring back memories of delightful and exciting contests on the athletic field. But do not let these constitute all of the decorations. Have a few good photographs of some of the great pictures. For instance, there is Raphael's "Madonna of the Chair," in which the beautiful young mother holds the baby Christ in such a close, loving embrace that she no longer seems a vague and shadowy person, but like a dear mother of to-day.

Another fine picture that one would do well to become acquainted with is by Rembrandt, and is called "The Syndics," a wonderful painting in a great museum at Amsterdam. "The Syndics," you say—"what *are* Syndics?" Why not look up the matter of "syndics," for when you have done so you will look at Rembrandt's picture with new understanding. If this picture is too "grown up," there is "The Shell," by Murillo, a lovely representation of two children, that will please you as much when you are thirty as when you are thirteen. Then, dear little "Penelope Boothby," and the "Strawberry Girl," by Sir Joshua Reynolds, are both winsome little lassies and good to look upon. There is also the beautiful stately Venus of Milo, of which one can never tire. A photograph or even a plaster cast of this lovely lady is not expensive. And some day, if you are so fortunate as to see the original in the Louvre in Paris, you will seem to be meeting an old-time friend.

Do not fill your room too full. Whether a girl takes care of her own room, or whether some one else cares for it, remember that neatness and order should come before fanciful decoration. And a room that is "easy to care for" stands a chance of being far more attractive than one overloaded with trifles.

As soon as possible after rising, your bed should be aired. This does not mean that you are simply to toss the bed-clothes over the footboard; it means to place counterpane, blankets or comfortable, and sheets on a chair, one by one, using care that no part of the bed-clothes touches the floor. Keep them as clean as possible. While you are at breakfast the windows should be opened and the room thoroughly aired.

Before making the bed, be sure to turn the mattress over; then put on the lower sheet, tucking it in smoothly on all sides. The upper sheet and blanket need be tucked in only at the foot, provided the counterpane comes down far enough on the sides to cover both sheets and blanket. Many people "tuck in" everything, sheets, blanket, and counterpane, but to open a bed made in this way at night, is to pull it almost to pieces. If the upper sheet, blanket, and counterpane are not disposed of so snugly, it is easy to turn down the bed-clothes with no danger of their disarrangement. It is easier to make up a modern metal bed in this way, than the heavier wooden bed of some years ago.

A girl's dusting equipment is simple—a very soft feather-duster for books and pictures, and a dust-cloth for furniture. The so-called "dustless duster" is so easily made that every girl may have one. Take a piece of cheese-cloth, or thin flannel, and wet it in kerosene. Then wring it out and allow it to dry out of doors. When dry it makes a capital "dustless duster" that will prove a real help to the little housekeeper, for it will hold all the dust it gathers and will last a long time.

If a girl may have a voice in selecting the furniture for her room, let her beware of fanciful patterns—one soon tires of them. But simple, harmonious lines are beautiful indeed, and a "joy forever." Right here let me tell you a story, true in every word. Not long ago, when visiting a certain artist (some of her lovely pictures are in these very books), I noticed a beautifully inlaid bookcase, and said to her:

"Where did you find such a lovely bit of Dutch inlaying? It is seldom one sees so fine a piece."

"There is a story," she answered, "almost a childish romance, connected with it. When I was only a small girl I was charmed with Dutch inlaying; I took a strong and unusual fancy to it. I saw the bookcase, and asked the price. As I had inquired the prices of several similar pieces of furniture, I knew something of its value. The price seemed reasonable, but I had only a very small amount of money at that time. I had, however, an allowance on which I could count, and Christmas was not far away. So I mustered up enough courage to call on the furniture-dealer, offer him a small payment at once (it *was* small, I assure you!), and the remainder as quickly as my allowance permitted. Of course, Christmas and birthday presents of money helped along amazingly. I suppose it was unusual for a little girl of fourteen to undertake buying furniture in this way, but the dealer con-

sented, and in time the bookcase was really my own!"

"But," said I, "you have many similar pieces. I hope, for your own peace of mind, that they were not all acquired in the same slow way."

"No," she laughingly admitted, "they were not. But my admiration for this particular style of furniture grew with my growth, and, as I could afford it, I bought similar pieces, until now I have quite a collection."

The artist's home is beautiful indeed, and it has been made so by careful planning, wise economy, and prudent purchasing. There is really a little lesson in this, is there not? For so often we fritter away our money on silly and extravagant things when we might, by a little thought and self-denial, have many lovely objects about us to enrich our lives with their unspoken and uplifting influence.

TEACHING HOUSEKEEPING

THERE is a certain lady in a Western city who is the mother of two busy little school-girls aged eight and eleven. School-work comes first, but every Saturday two hours are devoted to domestic duties. These are learned in the most delightful way possible; it is almost like playing a game, for the mother begins by saying:

"Well, what is out of order to-day? What shall we do first?" The answer must not be haphazard, but must come from careful investigation. One day Frances replied:

"Shall we dust the parlor? The piano-keys were dusty yesterday afternoon."

"They are not dusty now," said keen-eyed little Kathleen, "for I've looked."

"Mother, is it the sitting-room closet that needs cleaning?"

"No," said Mother, "but you are getting warmer. Guess again!"

"Is it—" faltered Frances.

"Your own clothes-closet," said Mother, "for I saw a sweater and skates on the floor (which was dusty), and two dresses hung up by their sleeves, instead of being hung up by loops made for that purpose. Come, let's see what else is out of order!" So off went all three to sweep and dust and rearrange and (incidentally) to have a right good time together.

After this hour of well-directed housework came one of sewing, principally mending. But in this short time, enlivened by pleasant chat and helpful hints, all repairs were made in dresses and underwear, all missing buttons replaced and stockings darned, as well as habits formed and knowledge acquired that would always be useful.

Then, the mother's way of asking what was out of order made the little daughters watchful concerning the care of the home, for they were pleased and proud when they could "guess," without any help, what work most needed to be done.

A GIRL'S OWN BUREAU

A BUREAU is surely the most important piece of furniture in a little girl's room, and how dainty and pretty it may be made, with a spotless white cover of linen bordered with lace or a simple edging. It is an easy matter to decorate a linen cover with hemstitching, embroidery, or simply embroidered initials. Nowadays a good assortment of letters for stamping may be had for ten cents; and a hot iron placed on a letter stamps it ready to embroider. A linen covering edged with linen lace, and with small embroidered initials in the middle of the front edge, makes one of the prettiest bureau-covers possible. A pincushion to match the cover could easily be made, and so arranged that its own cover could be removed and washed. Some girls like the bureau-cover and pincushion made of barred or dotted muslin, lined with a delicate pink or blue. This often adds a delightful bit of color to the room.

A little tray of china, or of Japanese lacquer, about six by nine inches, on which to lay brush and comb, is a real convenience on a bureau, and helps to keep the cover spotless.

Do not put so many knickknacks on your bureau that the thought of dusting it makes you sigh in despair. Most of a girl's small belongings may be kept in the top bureau-drawer, for here they can be completely shut away from all dust. Underwear may be kept in the lower drawers, and pretty blouses and "the Sunday best" in the lowest drawer of all.

A CONVENIENT CLOSET

EVERY bedroom should have a closet. Sometimes bedroom closets are large and roomy; others are so small as to require careful planning in order to make them hold all they should. Hats and similar belongings find places on the shelves. The principal drawback is lack of room for hanging clothes. Of late years a capital device has appeared, which has proved a boon in many small houses, and its simplicity is the best thing about it.

Buy a long, smooth, wooden pole upon which heavy curtains are often hung. The two rings for securing the ends of the pole to the window or door will come with it. Measure the length of

your closet, and cut the pole to that length, so that, with the two supporting rings properly fastened to the wall, the pole will extend the entire length of the closet, and will be firmly fixed. The height of the pole above the floor may be determined by the size of the person who is to use it. It would indeed be a convenience to a little girl to have one of these poles so placed that there need be no straining for hooks almost beyond her reach.

The long pole must be furnished with a number of everyday, five-cent coat-hangers, on which waists, coats, and even skirts may be so easily hung and pushed along on a pole that the number of garments that can be easily contained in one small closet is quite astonishing. When the little owner of the new-fashioned closet wishes to

"clean house," it is easy enough to unhook one hanger after another, with garments still attached, and to lay them over a chair. She will soon have an empty closet which may be cleaned with facility and speed.

While few little girls are equal to the task of sweeping, the lighter work of the house may be safely undertaken by them, and every loyal little daughter should take a personal pride in her home. It may not be big or rich or elegant, but any home, however plain, may have an atmosphere of refinement and cheer, may be a place from which simple and sincere hospitality radiates like a genial sun. And to be bidden as a guest to such a home, to enjoy its sunshine, and to take part for a time in its life, is assuredly a rare and delightful privilege.



LITTLE HOUSEKEEPERS AT WORK.

WITH NEEDLE AND THREAD

A LITTLE GIRL'S SEWING

WHAT a delightful thing it is for a little girl to have a workbox all her own! Only sometimes instead of a box it is a dainty little basket, prettily lined. In stores where Japanese goods are sold we may find pretty boxes of lacquered wood, and these make very nice workboxes.

Occasionally, however, a little girl likes to make her own workbox, and this is the easiest way to do it. Take a cardboard box of suitable size and carefully pull it apart at all seams until, instead of a box, you have the five pieces of pasteboard which formed it; namely, the four sides and the bottom. Then cut out of cardboard a duplicate set of five pieces, only this second set must be just a trifle smaller—about an eighth of an inch. Cover the pieces with pretty cretonne, silkolene or silk, and then put them together. For instance, take the two larger pieces which form the bottom, and after covering them smoothly with long stitches going from side to side at the back, where the long stitches will not show, put the two “wrong sides” together and overhand neatly around the edge. Now the bottom of the box is ready, for it is neatly covered on both sides. All five pieces must be covered in this way. These five pieces may be fitted and sewn together like the original box. Of course the smaller pieces form the inner part of the box. If desired, they may be covered with a different color from the outer part. For instance, if you have a flowered cretonne with pink roses for the outside, the lining may be of plain pink silk.

It is an easy matter to make a lid for this workbox—a cover which shall protect the contents from dust. Take a piece of cardboard large enough to just cover the top, and after it has been lined it may be attached to the box by a few loose stitches made of heavy twist. These will serve as little hinges to the lid.

Possibly you may wish to pad the lining of the lid by placing a sheet or two of cotton batting

between the cardboard and the lining, and perhaps add a few ribbon loops in which to stick scissors and other small conveniences. A silk cord running round the outside of the seams and cover makes a pretty finish.

And now, what should the workbox or workbasket contain?

A medium-sized pair of scissors; a tape-measure that rolls up snugly; white thread Nos. 40 and 60; black thread Nos. 40 and 60; a spool of black twist, letter “C”; a glove-mender (and a little glove-mender of silver makes a pretty present; one of celluloid costs only a few cents); a thimble, a little needle-book containing needles of assorted sizes, and a tiny box of metal to hold buttons.

This little box does not conflict with the “family button-box”; it contains only a dozen or two of buttons such as may be needed at short notice for gloves, shoes, or underwear.

And with a charming little workbasket or workbox always at hand, what little girl would object to an emergency which meant sewing up a tear or replacing a button! Not one, I am sure.

A LITTLE GIRL'S MENDING

How many girls know how to thread a needle properly? Why, everybody knows how to do that, you may answer. But wait a moment. Take a piece of thread and run it through your fingers. In one direction it feels smooth and silky, while in the other direction we feel a slight roughness, as if you were stroking it the wrong way, just as you might stroke the nap of cloth the wrong way. Of course if the thread is pulled through the cloth again and again in the wrong direction it soon becomes rough and twists up into ugly tangles and knots. It is easy to prevent this. If you thread the end just cut from the spool, the thread will remain glossy and smooth. There you have the secret in a nutshell.

In darning stockings the darning-thread should



Asther Peck.

"FINE FEATHERS MAKE FINE BIRDS."

be soft, but not too coarse for the texture of the hosiery, which it should match in color. We begin the darn at some little distance from the hole, putting no knot in the cotton. We run the darning-cotton back and forth in even, parallel lines, loosely, for it will shrink a little in washing. Then, we turn the darn halfway round and make other parallel lines at right angles with the former, this time "weaving" our stitches regularly under and over the lines already worked. In this way we really form a new fabric which is more durable than the original material.

Do not have the outlines of the darn square and well-defined. Have the edges irregular and uneven so that the darn may merge into the material and have no sharp edges that might be felt by a sensitive foot.

In mending kid gloves, use fine thread, rather than silk, of the same color as the glove. Turn the glove or finger wrong side out, use as small a needle as possible and sew up the rip with tiny stitches. It is far better to use thread for this purpose, as silk is likely to cut the kid. Silk gloves should, of course, be mended with silk of the same color.

When a garment becomes worn or ragged in one part, and the possibility of darning it is hopeless, we have to patch it. For the patch we need a piece of material to match the garment. This is important, for it would not do to use thinner or heavier material. If the color of the garment has faded, and we have a piece of unused cloth in which the color is bright, we may cause the new material to fade slightly by hanging it out in the sunlight, or washing it in water in which a little washing-soda has been dissolved.

Suppose a hole appears in a white apron and the little owner is going to put on a patch. She places a piece of the same material over the hole, cutting the piece in a square or oblong, as may be needed. This patch should be somewhat larger than the hole.

Place the apron right side downward on a table and lay on the patch. Pin it in place and turn the edges under; then baste them down before hemming. Now turn to the right side of the apron, cut away almost to the edges of the patch, turn the edges under, and hem them down. If done with neatness and precision, a patch of this kind is almost ornamental!

In patching a material as heavy as flannel, do not hem down the edges of the patch; do not even turn them under, for they would make a thick ridge. Fasten the edge down flat, with some loose

stitches, and then, with small stitches, darn the worn portion on to the new patch.

In patching cotton goods with a stripe or a figure, be sure that the patch matches the goods, for if carefully put on, the patch can hardly be seen.

A LITTLE PATCHWORK

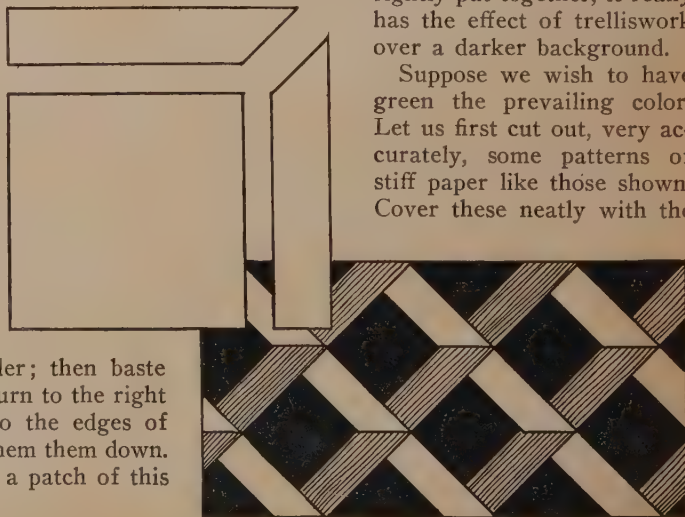
"PATCHWORK!" some little girl may exclaim contemptuously. "Why, nobody does patchwork any more! It's too old-fashioned."

Patchwork is old-fashioned, but we must remember that in the days when this work flourished materials of all kinds were scarce and every bit of precious "cotton cloth" had to be put to use. There was no discarding a dress or an apron just because it was faded, or because the pattern was no longer fashionable; such wastefulness was not tolerated years ago.

And what was the result of this economy? Many a housekeeper of to-day has, carefully put away in her linen-closet, one or more choice "patchwork quilts," so daintily made that we can only wonder at the skill and patience that produced them. Such elaborate pieces of work have had their day; and while a quilt is a big undertaking, some little girl may wish to try making a cover for a sofa-cushion, following the suggestions here given.

To make the pretty "trellis pattern," three different shades of the same color are needed. Now, note the following diagram. You see that, if rightly put together, it really has the effect of trelliswork over a darker background.

Suppose we wish to have green the prevailing color. Let us first cut out, very accurately, some patterns of stiff paper like those shown. Cover these neatly with the

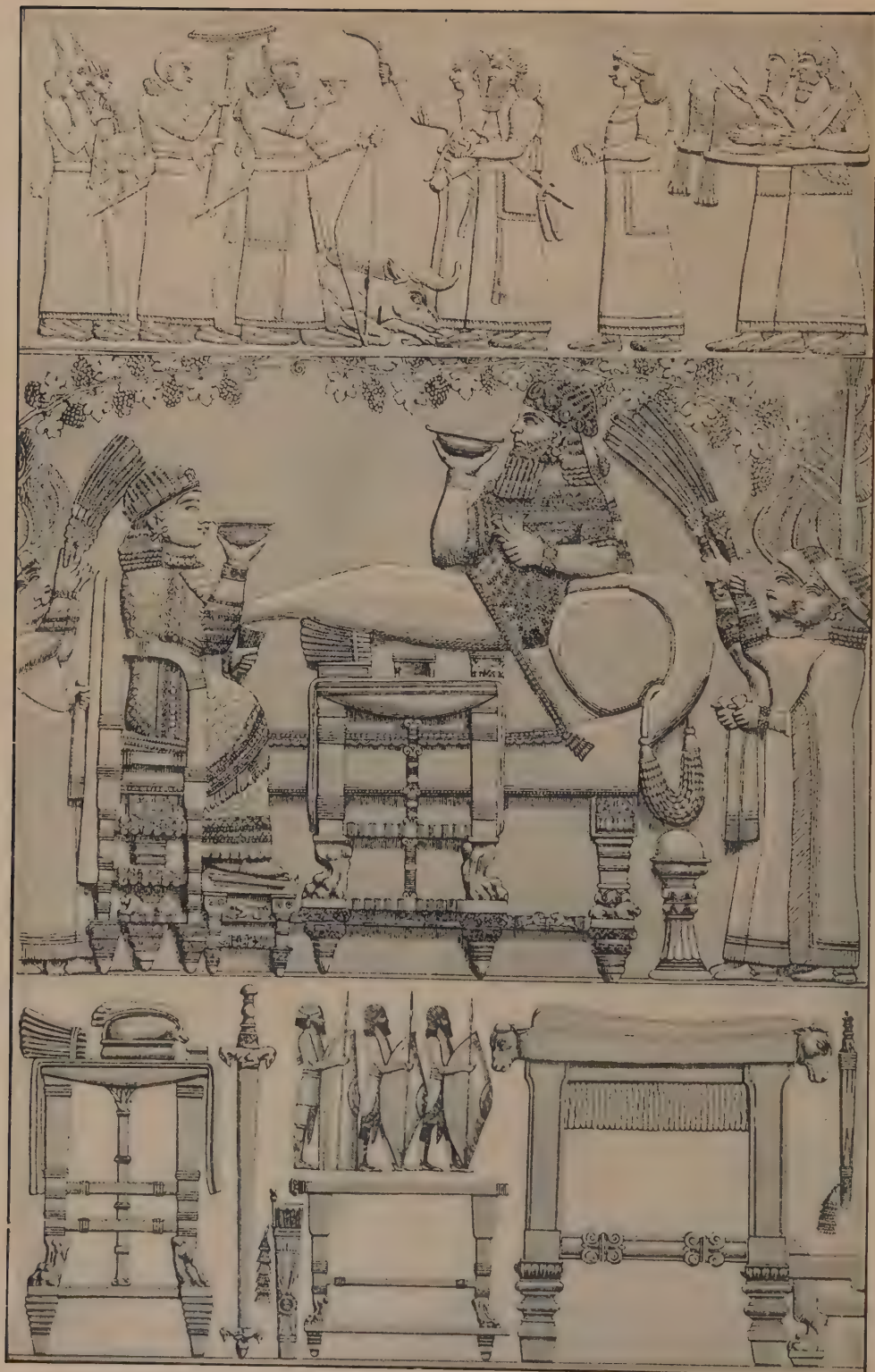


TRELLIS PATTERN AND DIAGRAM.

material to be used. Let us use a flowered green pattern for the square, and two shades of plain



Costumes (1) from Ancient Egypt to the 15th Century. *Upper line from left to right:* Egyptian king and queen, an Assyrian (1400 B. C.), Greek gentleman and lady, and Roman gentleman and lady. *Lower line:* Byzantine emperor and empress (10th century), Frankish noble (9th century), French knight (13th century), a knight of the 14th century, knight and queen of the 14th century, and Flemish lady of the 15th century.



ROYAL ASSYRIAN COSTUMES AND FURNITURE

green, light and dark, for the sides. You notice that these sides, one inch wide, may be moved close to the two-inch square, thus forming a perfect three-inch square. The "trellis" effect, however, is more distinct if these side-pieces are narrower. To effect this, cut a strip from the outer edge of both side-pieces, as shown.

When we have cut out eight or ten paper patterns we may begin sewing. The paper square should be covered with the green-flowered material, the edges being carefully turned over the paper and basted. In the same way cover the side-pieces, one with light green, the other with dark green. When sewed together, the result is a three-inch square. Make a number of these squares before sewing them together; and when you come to that interesting part, be sure to have the light side in every square in the same position, then the "trellis" effect will be quite perfect.

Try this pretty patchwork pattern. Make it in flannel, cretonne, gingham, or even silk. Begin by making a cover for a sofa-pillow, and when you have finished it—who knows?—you may decide to use larger squares and make a lovely bed-quilt that shall rival even the beautiful work of our great-grandmothers.

PLAIN SEWING FOR CHILDREN

BY FLORENCE KENDRICK COOPER

EVERY girl wants to learn to sew. Sewing is natural to "little women," just as hammering is to "little men." It is a most attractive occupation. There is nothing more sociable and comfortable than to sit down with Mother, or with a group of playmates, and "make something"—especially some real thing—to wear, to have a doll wear, to use, or to give away.

The word "plain" before "sewing" sounds rather dry to little girls; but, as a matter of fact, no kind of sewing is plain in the sense of not being interesting, nor is it plain in the sense of being exactly easy. It looks very easy when Mother takes the neat stitches that turn a queer-looking piece of cloth into an ornamental or useful article; but before she could do it well, that same Mother had to practise on a great many smaller articles.

Learning to sew is like learning anything else. It cannot be done in a minute. It must be done by steps, and by doing the right kind of work in the right kind of way.

For instance, the right kind of work for Margaret, eight years old, is not the right kind of work for Jean, who is twelve years old. And

Elizabeth, who is fourteen, can do a good many things that at ten she could not have had the least idea how to do. There is pleasant "sewing-work" for all ages.

We will talk first about some of the things that Margaret can do. But before she begins to sew, there are several things for her to attend to. She must get her low chair, without arms, low enough to let her feet touch the floor, and with a straight, strong back to make her feel supported as she sits at work. If the little sewer leans over, or has to swing her feet, she will get very tired, and will injure her delicately and wonderfully made body. Her hands and nails should be so clean that they will shine, and her hair should be neatly tied back out of her eyes. Hands and feet and eyes and backs are precious tools, and though we can buy new needles and thread when we need them, if we lose those tools they never can be replaced.

When Margaret is seated in her low chair, with a pretty apron on, if she has one, she can take some outing-flannel, or soft cretonne, and cut—or ask Mother to cut—a piece about eighteen inches long and five or six inches wide. She has made up her mind that a bag to hold Mother's buttons will be a very useful thing to have. So she will make one. After cutting her cloth in this way, she must fold it together just doubled, so that there will be no seam on the bottom, lay the sides evenly together, putting in small pins to keep the edges in place (never use large, coarse pins about your work), and then she must get her needle and thread. The needle must have a large eye, and the thread must be a white cotton—luster-cotton is very nice—and she must begin at the bottom about a half inch from the edge. Her stitches should be even, but not very small—about eight stitches in an inch. She must try to keep half an inch from the edge all the time.

When she has sewed up the sides, she must fold a hem about one and a half inches wide, and she can sew that down with the same kind of little stitches, although when she is a year or two older she will make a hemming-stitch for that. When her hem is made, she can run a tape into it for a string, and she will have a very useful bag. She can put some of her doll's things into it, if she wishes to, or she can keep her sewing in it.

Jean, who is twelve, can make something that takes more skill. An apron to wear when she is sewing, with pockets in it; a simple cover for her bureau or the table in her room; straight sash-curtains for her windows—these are pleasant things to make. For any one of these there is nothing prettier than a white lawn, either plain

or striped, from twelve and a half cents to fifty cents a yard, with a finish on the edge of some kind of narrow imitation lace. An apron should have a straight whole front, the width of the cloth, and a half-width on each side of that. To make the pockets for work, the hem is turned up on the right side, and then the edge is covered with the simple lace. Jean can make the width of the pockets to suit herself, by sewing the back and front of the hem together in different places. Her needle must be much finer than Margaret's, No. 7 being about right, and her thread should be about No. 50. She must make a hem an inch wide at the top to receive a ribbon, which will serve for apron-strings. Almost any girl of twelve will have seen such aprons and will have ideas of her own, which she will enjoy carrying out. She can make a great variety of pincushion-covers on cross-stitch canvas, worked with crewels in pretty colors. That sort of work is very fascinating.

Girls of fourteen ought to know how to sew nicely. They might even make, under Mother's direction, a simple unlined shirt-waist; and by imitating the linen jabots in the shops, which are often quite expensive, although very simple in the making, they can have a variety of these dainty articles, which have to be changed frequently. They can do filet-work, which is simply darning on canvas with pretty colors. Such work decorates a room very prettily.

Speaking of darning brings me to a very important branch of this subject. Holes will come into the best regulated hosiery. They begin, like most holes, small, but, if neglected, they increase in size as well as in number. Nothing speaks better for the work of a girl of fourteen than a hole *handsomely darned*. It is more to her credit than an embroidered sofa-pillow. And the pleasure of doing nice darning is quite as great as that of any fancy work. Fine darning needs instruction on the spot. But it may be said, in general, that the edges of the hole must lie loosely and naturally, that the threads of silk or cotton must be evenly begun and ended, and the over and under must be as nearly perfect as possible. A

darn made with care is really almost an ornament, and will sometimes outlast the material of the garment itself.

And speaking of darning makes me somehow think of buttons. If there is anything more important than anything else, it's a button! There is hardly a child too young, and there is certainly no woman too old, to know the value of a well-sewed-on button or hook and eye.

When you are in a hurry for school, or to go skating, or to get down to breakfast, is there anything more exasperating than to have that button in the middle of your back—hard enough to reach, at best—fly off, leaving you in a bad fix? And how uncomfortable to find a "wabbly" hook or eye on your skirt-band or your collar! Every girl, little or big, should make it a habit to watch her buttons and hooks. If she is not quite old enough to sew them on herself, there is sure to be a mother or an aunt or a sister who will do it. But if she is a big twelve- or fourteen-year-old little woman, she should take a pride in keeping her fastenings all trim and tight.

There is an old saying, "Trifles make perfection, but perfection is no trifle." Buttons, hooks and eyes, strings,—these are some of the trifles that give perfection to a child's appearance, if they are well taken care of, and even little children may begin to think about their importance.

There are many useful and ornamental things that children from eight to fourteen can make and will enjoy making—simple doll's clothes; kimono sacks, even for themselves; shoulder-coverings, to wear when combing the hair, made of fancy toweling; holders, book-marks, and many other articles. The important points are that every article should be a *real* thing, to be used when finished, and that it should be insisted on that the work be done well. Plain sewing is really very interesting if it is done with care—adapting the means to the ends—with patience, with a willingness to learn, and a resolution to do the best possible. And child Margaret at eight can show all those traits, as truly as a great painter and a great singer while they are learning their art.



DOLLS IN COSTUMES OF MANY NATIONS

THERE is hardly a little girl who does not own at least one doll; and there are many who own whole families of dolls—father-dolls, mother-dolls, and dozens of doll-children. Usually they all are members of one family, and that family is very much like the real family of the little doll-owner.

Now here is a new idea. Instead of having the dolls all similar, why not dress them like little people of other nations? You may think that this will prove a hard task, but if you follow the directions here given it will not only prove an easy task but a delightfully interesting one. The dolls need not be more than nine inches long.

Begin with a single doll and add others as you can. Take your time for it. Let each little doll-dress be carefully and correctly made and the result will be so charming that grown people, as well as children, will be delighted.

The picture on the next page shows a number of these prettily dressed dolls. We must, however, know more about their costumes than the picture shows; we must know the proper colors and materials to use in making the dainty dresses. The accompanying directions, if carefully followed, will produce charming results.

No. 1. GRETCHEN, THE GERMAN DOLL

IN choosing our German doll we must see that she has long, light hair, almost yellow in color. She should have a plump little figure and pink cheeks.

The German peasant has a special costume which is worn both week-days and Sundays. Its most striking feature is the curious bonnet with its straight front, quite stiff and plain, and full-pouched back. It is plainly shown in the picture. It should all be made of cotton material of two colors. The back part should be white, and the stiff part, which goes round the face, should be pale blue, edged with a tiny frill of white.

When we dress our German doll we must part

her hair and braid it in two "pigtails," fastened at the ends with small bows of red ribbon. The soft white lawn blouse is cut rather low in the neck. It is full and pouches just a little over the top of the bodice Gretchen wears. This bodice is made of black velvet, and is a straight band in shape, supported by two narrow strips going over the shoulders. It is laced up at the back.

The skirt is of cloth or muslin; dark blue is a good color. Make it full and gather it into a plain band. It is put on after the blouse; and the bodice, which is a sort of waist, fits neatly over the skirt-band. The apron has no bib, but it has a tiny pocket. It is made of white muslin, with a little ruffle at the bottom. You will notice that this ruffle goes a little way up the sides of the apron.

The stockings are white and the slippers either brown or black, with low heels, broad, and comfortable in shape. The sleeves are small, and finished by a little band which comes just to the elbow. If we can buy or make a tiny hay-rake, our little Gretchen will be completely equipped for her work in the fields.

No. 2. SARAH, THE ARMENIAN DOLL

THE complexions of the Armenian people are olive, the hair black, the eyes dark; and the women are noted for their long lashes. Though their features are large, they are considered a handsome race.

Sarah's costume is of cotton material, for it is hot in her country. The skirt is full and short enough to show her feet. The material should have a well-defined pattern of rich colors. The little waist is tight-fitting, with long sleeves that end at the wrist in a plain little cuff. The skirt is sewed to the waist, which is fastened in front with a few buttons; it has no collar.

Over this dress is a coat that is much like another dress, for it has a full skirt joined to a plain top. The skirt of this coat is shorter than the



DOLLS IN COSTUMES OF MANY NATIONS.

1. GERMAN DOLL; 2. ARMENIAN DOLL; 3 AND 4. DUTCH DOLLS; 5. RUSSIAN DOLL; 6. SPANISH DOLL;
 7. SWEDISH DOLL; 8. FRENCH DOLL; 9. HUNGARIAN DOLL; 10. JAPANESE DOLL;
 11. EAST INDIAN DOLL; 12. ESKIMO DOLL; 13. ITALIAN DOLL.

figured dress-skirt, as shown in the picture. The sleeves of the coat come only to the elbows; they are finished with a little ruffle of the same material, which, by the way, is a plain dark blue or dark purple cotton cloth.

Over the coat Sarah wears an apron. There is plenty of stuff in the apron, but it is all gathered so closely that it does not cover much of her dress. It is made of white cotton material with wide border of blue or figured goods.

The head-dress is very simple, a bright red square of cotton cloth folded round her head; for this doll represents an Armenian girl whose duty it is to fetch water in the cunning little earthen jar slung over her shoulder by a cord.

NOS. 3 AND 4. PIETER AND WILHELMINA, THE DUTCH DOLLS

BEFORE we begin to dress these dolls, let us look at their pictures very carefully. Let us commence with Pieter, whose costume is very easy to make because it is loose and comfortable as well as warm. He wears extremely baggy trousers reaching to the ankles. These should be made of dark blue cloth, and cut very full. His short little coat is of dark gray cloth, and is buttoned up to the neck. Underneath is a red striped waistcoat, the collar of which can be seen just peeping above the little coat. At the waist are worn two silver-colored buttons, always of large size. At the throat the red waistcoat is fastened with two tiny gilt buttons, while the buttons that fasten the coat are supposed to be of silver. The buttons of a Dutch boy are his jewelry, and he is very proud if his clothes are well ornamented with them.

Pieter's thimble-shaped hat is of cloth or felt, and fairly tall, but with no brim. It must be made to fit properly. It is worn on the back of the head with an almost rakish air.

Sometimes wooden shoes—sabots, as they are called—are for sale in toy-shops. If these cannot be found, possibly skilful fingers may fashion them out of cardboard cut and glued into shape. These are rather difficult to make. Pieter must have light hair, short and straight. He must have a healthy, rosy complexion.

The little Dutch girl, Wilhelmina, wears a cap of white lace or embroidered muslin. It fits tightly on the head, and has wide side-pieces, which turn back from the face and form flaps, or "wings." These caps are stiffly starched to make the wings stand out, so we must make our doll's cap of stiff muslin. If we use lace for it we must insert a fine wire at the edge.

The little waist, of flowered material, is tight-fitting, with elbow-sleeves. It is cut square in the front and worn with a chemisette of white. The square-cut neck is bordered with a band of some plain color. The apron should be of white or blue with a strip of checked material at the top. There is no bib to this apron, which is on a plain, narrow band buttoning at the back. The sabots should be the same as those worn by Pieter.

While most ladies prefer to look slim, the Dutch lady, to be really well dressed, must look as large as she conveniently can, and the more woolen petticoats she wears the more is she pleased with her appearance; so do not be afraid of putting too many skirts on our flaxen-haired doll, Wilhelmina. Her skirt should come to her ankles and the petticoats be of the same length. Round her neck she should wear several rows of coral-colored beads held together by a tiny clasp.

There are many peculiar costumes worn in Holland, some of them much more elaborate than those described; but they are all more or less alike in some respects.

No. 5. IVAN, THE RUSSIAN DOLL

BESIDE Wilhelmina stands little Ivan, the Russian. For this let us buy, if possible, a boyish-looking doll with short, light hair.

As Russia is a cold country, we must dress Ivan in fur. But first he must wear a navy-blue sailor-suit such as other small boys wear, and to this must be added a pair of top-boots made out of soft kid or thin leather of the shape shown in the picture. But little Ivan will need an overcoat, and the picture shows that it must be trimmed with fur. Still, as fur would be clumsy on so small a garment, we can easily substitute a little Canton flannel or any other cloth with a long, furry nap. The collar, cuffs, coat-lining, and cap should all be made of this "fur." Tiny "frogs" of narrow black braid can be added at the front, as shown in the picture.

No. 6. DOLORES, THE SPANISH DOLL

THE country of Dolores is often called "sunny Spain," because the climate is warm, bright, and full of sunshine. People who live in hot countries appear to love bright colors, so the Spaniards are fond of gay, glowing hues, and therefore little Dolores must be gaily dressed. She must have dark hair, and it must be "gone up" quite high, as shown in the picture, with a tiny red rose coquettishly placed at one side.

Spanish girls are fond of little silk shawls, so for our doll's shawl we must get a square piece of soft silk, brightly colored—brilliantly, in fact—for it needs an orange ground with red and green flowers on it, or else a pink ground with a small pattern in purple, deep red, and blue. Sew fine black silk fringe all around the edge, and the shawl is made. We must fold our shawl from corner to corner and put it round the doll's shoulders, as shown in the picture, crossed in front, with the ends tied loosely behind. The fringe, you notice, is quite deep in proportion to the size of the shawl. The throat should be decorated with one or two rows of colored beads.

The skirt, which is short enough to show the ankles, is of an ordinary shape but made with a ruffle on the bottom, or rather with a series of little box-plaits.

The stockings are white, the shoes black, held on by the pretty little cross-gartering, which can be made of narrow black ribbon. Fix an end of the ribbon to each side of a shoe, then bring the ribbon round and cross it back and forth.

The cotton apron is striped in several colors—blue, green, and red, or perhaps pink with delicate purple stripes; certainly, it must be very bright.

Usually a Spanish girl will wear a lace scarf, or mantilla, to drape the head and shoulders. It looks very charming, but it is not worn with the fringed shawl. At a place of amusement it takes the place of a hat.

No. 7. GRETA, THE SWEDISH DOLL

NEXT we come to the little Swedish doll, whom we call Greta. Though Sweden has a warm summer, its winters are long and cold, which explains why warm clothes are typical of this country. The girls and women are very industrious and fond of fine needlework with which to decorate their clothes. They make delicate little patterns on the children's caps and bonnets and think nothing of embroidering a child's coat all over. All of their household linen is beautifully embellished with skilful handiwork. When Swedish ladies go out to tea they frequently take with them a bit of embroidery to do, and the work done by some of the children might put older people to shame.

As the picture shows, Greta wears a little white blouse of fine muslin gathered into a straight neckband; a vest of red and black striped silk, fastened in front with tiny gilt buttons. If the striped silk is not easily found, the right effect may be produced by using red silk on which

black lines have been made either by embroidering them or by sewing on black braid.

The jacket is made of dark, bluish-green cloth; and here comes in the embroidery, which covers it in a pattern composed of triangles and lines—not at all a difficult one to copy. It is worked in black wool, the triangles filled in, and the lines outlined. It will be found far easier to cut out a plain, tight-fitting shape, and embroider it, before putting it together, than to put the coat together and then embroider it.

The skirt is full, made of black cloth, with a band of scarlet cloth around the lower edge. The apron is dark blue, and not of cotton material, as we might expect it to be, but of cloth. On the cloth is a pattern of fine white lines, which may be made by white threads run evenly through the surface of the cloth.

The little pocket, suspended on a red silk cord, is a fascinating detail. The pocket is dark blue or red at the back, with a white front forming the pouch. This white portion is ornamented with a square cross of red cloth sewed on with white thread; the stitches show, and form white spots or crosses round the edge of the red cross.

The cap is a marvelous combination of color; but copy it carefully. It is of bright red satin with yellow and blue flowers and leaves embroidered on it. It is somewhat pointed in front, and shows the hair well at the back. The little slippers are black and the stockings are white.

No. 8. HENRIETTE, THE FRENCH DOLL

FRENCH women are noted for their good taste in clothes, and the little French girl always looks very neat. The rich like to dress their children elaborately; their little frocks are beautifully made. So we must dress the French doll, Henriette, very daintily.

The dress should be of light blue silk, and under it should be worn very full petticoats, generously trimmed with lace. The sash, of plaid silk, with fringed ends, is worn a little below the waist-line. The hat is of puffy white mull trimmed with cunning little bunches of blue ribbon, to match the dress.

Little children in France wear short white socks and pretty boots of patent leather, with tops black or tan in color. Henriette must wear tiny pearl beads round her neck, or perhaps a string of little pale coral-colored beads. She should wear one or two gold bangles on her arms and a little bow of blue or black ribbon in her hair. She should carry a cunning little parasol.

For a French doll we must choose one with a pale complexion and dark hair.

No. 10. LOTUS BLOSSOM, THE JAPANESE DOLL

No. 9. PANNA, THE HUNGARIAN DOLL

As in nearly all of the European countries, it is only the peasants in Austria and Hungary who still wear the national dress. Our little Hungarian doll should have a round face, pink cheeks, and brown hair.

Her cap or bonnet is one of the prettiest head-dresses imaginable. It is made of white or cream-colored linen, and beautifully embroidered in the brightest red, green, and violet silk that it is possible to buy. The shape of the cap is very simple, for it is made of two straight pieces of material.

The embroidery on this cap must receive special attention if we wish to make it really characteristic of Hungary. To succeed in this we must arrange, in some pattern having few angles, a number of bean-shaped figures. These should be worked in geranium-red and pinkish red. These colors are not often combined, but they look quite charming on our little Panna. Parts of the design must be filled in with violet and a soft, grayish green. The background must be filled in with red so that no material shows—just a solid mass of embroidery. A tiny ruffle of light, tan-colored lace must edge the cap.

For the skirt and blouse white washable material is used, embroidered all over with the same figure, repeated again and again. For this part of the costume a simple cross-stitch is used, and the colors are black and red. In the picture you will see how the pattern is arranged. Skirt, blouse, and sleeves are rather full; the sleeve is finished with a little ruffle of lace at the wrist.

The coat, which is plain in shape and without sleeves, is made of dark blue cloth lined with red silk. The edging of the coat is a strip of white cloth "pinked" to form a border, and sewed in between the coat and its lining so that only a narrow edge shows. There must be two rows of tiny buttons on the coat, silver-colored and very bright.

Perhaps the coat may best be described by calling it a sleeveless Eton jacket, for it reaches only to the waist-line. It is a jaunty little garment, even though the outside is of sober blue.

The little apron matches the dress in color and material, except the border that edges it, and which appears again just inside the embroidered figures. The sash is of bright red woolen material, and the necklace is a double row of beads, black and red threaded alternately.

THE costume worn by the little Japanese girl is one of the most beautiful in the world. The Japanese are famous artists and can make lovely objects out of the simplest material. They have a great love of color and know how to blend colors with wonderful skill. We shall find their clothes made from almost straight pieces of material. We shall also find the colors very beautiful and well arranged. Nearly every city of our own land has one or more stores in which Japanese goods are sold, and it will be easy to find in such a store a doll that really comes from far-away Japan, with smooth black hair, slanting eyes, and tiny feet. In the same store Japanese chintz can be bought, and half a yard should make little Lotus Blossom a charming kimono. Nothing could be simpler in shape than a kimono, a pattern for which may be made as follows: cut out a piece of paper 4 x 8 inches; then cut out two more pieces, each 2 x 4½ inches. Place these smaller pieces, which are for the sleeves, at the upper part of the larger piece, so that the straight line across the top, including the sleeves, measures eight inches. This block-shaped outline will, if made of chintz doubled over, form a little kimono.

The front and back of this garment are alike, except that the kimono opens in front; so we must sew it together down the sides and cut it open in the front. The wing-like sides are the sleeves and the lower portions of these roomy sleeves are sewed so as to form large pockets. The neck may be cut out a little, in order that it may fit easily, and if a straight band of some plain material goes round the neck and down both sides of the front (where the garment opens) the effect is very pretty indeed.

The sash may be of some rich material, brocade or gold.

The Japanese girl is very particular about her sash and the way it is tied. It should be wide in front and at the back it should have one loop going up and another going down.

To dress the hair of a fashionable Japanese girl takes at least two hours, so it is not surprising that the task is not repeated every day. One dressing is expected to last for two or three days. Of course a hat would spoil this elaborate arrangement, so no hat is worn in the street. A paper parasol is carried, however, and it will be easy to find a tiny paper parasol for Lotus Blossom, as they are for sale in all Japanese stores and cost five cents or less.



POLISH COSTUMES OF THE SIXTEENTH AND SEVENTEENTH CENTURIES

Upper Section: Costumes of the Middle Class and Workmen

1, 3. Officers of the King's Guards

2 Commander-in-chief

4-8 Officers and Soldiers of the Regiment of Janizaries

CURIOSITIES OF CLOTHING AND COSTUME

THE BABY'S CAP

BY N. HUDSON MOORE

A VERY simple thing it seems, does it not? Just a little piece of soft, warm cloth, or some downy wool knitted into shape, or even some bits of fine lace or silk, or anything dainty, might go to make so small a thing as this.

But while we may pick and choose and do exactly as we please about our clothes, there have been, in times gone by, in many countries, and even in our own, what were known as "sumptuary laws." These laws regulated expenditure for dress, for ornament, for food, or for whatever refreshments you might give company when they came to take tea.

Among the first of these sumptuary laws was one made in Rome in 215 B.C., and called the "Oppian Law." It declared that no woman should possess more than half an ounce of gold, wear a dress of different colors, or ride in a vehicle in the city, or within a mile of it except on occasions of public religious ceremonies. This law lasted only twenty years.

Italy and France are the countries where most of these laws have been passed, and some of them read very strangely. In 1330, in Italy, no woman was allowed to wear a dress with figures painted on it; she could only have them embroidered. And in 1348, in the same country, neither dark green nor black dresses were allowed to be worn in the morning.

During the early portion of 1400 no woman or girl could wear more than three rings, and even these could have only one stone or pearl in each. The next rule in this set of seven is so strange that I give it just as it reads:

"Item. No person in the city, suburbs, or district of Florence shall permit himself or presume to give in any way to any woman any kind of collar, or buckle, or garland, or brooch of pearls, or of gold, or of silver, or of any other precious

stone or similar thing, by whatever name it may be called."

Of all things, however, lace has had framed more rules and regulations regarding it than all other materials of dress or ornament; yet, somehow, it was generally managed that a piece of lace could be used at least for baby's cap, laws or no laws.

The first step toward making lace was the manufacture of what is known as "cut-work." This was embroidery with part of the stuff cut away so as to show open-work.

Then came "drawn-work," in which threads were pulled from some coarse material, and a design or pattern was worked among the remaining threads with a needle and silk or flax.

Next appeared what we call lace, either worked with a needle in shape of points, or made of gold or silver threads twisted together. Of course this latter lace was very costly, and it was on account of the many laws passed against gold and silver lace that the attention of artisans was turned to making similar trimming, but with threads of flax.

As early as 1414 much gold lace was made in many of the larger cities of Italy; among those leading in this work were Florence, Milan, Venice, and Genoa.

The earliest laces, called "point" because shaped in points—sometimes they were also called "Gothic point" because the patterns used were like those which prevailed in Gothic architecture—were geometric in design.

The portrait of the baby with the parrot on its hand was painted, over three hundred years ago, by a very famous Dutch artist named Mierevelt. Nobody knows now whose baby it was, but I am sure its mother loved it very dearly, and I think perhaps her fingers embroidered the quaint

floral designs which show so plainly on its little coat.

Besides the beautiful Gothic point on the cap, the ruff also is trimmed with it, and it often took

a picture of him was painted over three hundred years ago by another Dutch artist, even more famous than Mierevelt! The name of this great artist was Frans Hals.



Photograph by Franz Hanfstängel.

CHILD WITH PARROT. FROM A PORTRAIT BY MIEREVELT.

twenty-five yards of lace to edge some of these triple-plaited ruffs, as they were called.

Another baby was a little Dutchman (I think the first one I have mentioned was an Italian), and

The fashions had not changed much when that portrait was painted, for the baby's cap, like the one by Mierevelt first mentioned, is trimmed with Gothic point. Instead of wearing

a thick, fluffy, all-around ruff, which was called a "gorget," this baby wore a half-ruff and stomacher of lace.

When Venetian lace had been brought to France, it was so much admired that Colbert, a minister of the time of Louis XIV., had factories started to make lace in France, so that the immense sums of money people spent for this fabric should be kept at home. Then Louis decreed that Alençon was the only lace which should be worn by his courtiers, but they did not always obey him, and still wore lace brought from Italy and Flanders.

A cap called a "Fontange" owed its origin to an accident. The "Sun King," as they called Louis XIV., was hunting one day, and a lady in the party, Mademoiselle Fontanges, had her hair much rumpled by the wind and the violent exercise. She tied her lace-bordered handkerchief over her head, and it was so becoming that the King desired her to arrange her hair in the same fashion and wear it at the court that evening.

The cap was admired, everybody copied it, and it was called, in compliment to the lady, a "Fontange."

We generally think that we have a great many things in this century that people did not have a century or two ago. So we have; but then they had things we should not know how to use.

There was a play called "Rhoden and Iris," first acted in May, 1631. In it is given a list of a lady's "ornaments." I will not name them all, but only a selection. I wonder how many of my youthful readers would know what to do with even the half of these!

Chains, coronets, pendans, bracelets and earrings;
Pins, girdles, spangles, embroyderies & rings.
Shadows, rebatoes, ribbands, ruffs, cuffs, falls,
Scarves, feathers, fans, masks, muffs, laces, caul's;
Thin tiffanies, cobweb lawn & fardingals;
Sweet fals, vayles, wimples, glasses, crisping-pins,
Pots of ointment, combs, with poking-sticks & bodkins,
Coyfes, gorgets, fringes, rowles, fillets & hair laces,
Silks, damasks, velvets, tinsels, cloth of gold,
Of tissues with colours of a hundred fold.



MANKIND IN CLOTHES

BY GEORGE MACADAM

LONG, long ago, when mankind was still in its babyhood, some hairy lord of creation happened to glance into a quiet pool, and saw mirrored in the water his own image. Comparing himself with the birds and the beasts, he saw that he was plain and dingy; and he became envious of

the brilliant-hued feathers of the birds, and the striped and spotted furs of the beasts. One day he discovered a bed of ocher. Sticking his finger into this bright-colored dirt, he saw that his finger became colored like the dirt. No doubt he stared in wonder for a long while at his strangely

colored finger; and then there gradually crept into his simple mind an idea which must have made him laugh for joy.

"Ha! ha!" he cried. "Here is my chance to give myself a new complexion—to make myself as bright and gaudy as Mother Nature has made the birds and the beasts."

So he daubed himself from head to foot with different-colored ochers until he was bright and many-colored. This covering of ocher was the original ancestor of the clothes which you and I are wearing at the present day.

In those early days man progressed very slowly. It was many years, perhaps even centuries, after he began to decorate himself with ocher that he invented weapons with which he could kill the birds and the beasts, and so rob them of their plumage and pelts. The feathers he stuck in his tangled hair, and the pelts he either threw over his shoulders like a cape, or tied around his waist as a sort of skirt. To this costume he added decorations of dried grasses and strings of shells. Like savages of Central Africa and the South Sea Islands at the present day, these prehistoric men did not aim at utility in their dress; their sole idea was to decorate themselves. So we see that even at this early date vanity had already been installed as Queen of Fashion.

How long this fantastic dress of pelts and feathers and shells remained "the proper thing" we do not know, for these antediluvians have left us no descriptions of themselves. But sometime in these early ages an unknown mechanical genius invented a loom and manufactured a rude sort of cloth. As this cloth could readily be cut and made into any shape or size, and dyed with ochers to suit any case, it began to take the place of animal skins for wearing apparel. Then the art of making and staining glass and working metals was discovered; and beads and metal ornaments began to take the place of shells and dried grasses. With these manufactures to his credit the primitive man was fairly started on the road to civilization.

When the curtain of history first rises, many hundreds of years before Christ, and we get our earliest glimpse of Egypt, we see a country al-

ready civilized. We could scarcely recognize the Egyptian gentleman who is being carried in a palanquin through the streets of Thebes, blandly smelling his favorite lotus-flower and nodding a recognition to his friends in the passing crowd, as a descendant of the half-wild man we left in the last paragraph, dressed in rough-woven, gaudy-colored cloth. His tangled locks have been shaven off, and he wears a wig made up of little curls. His beard has been trimmed short and



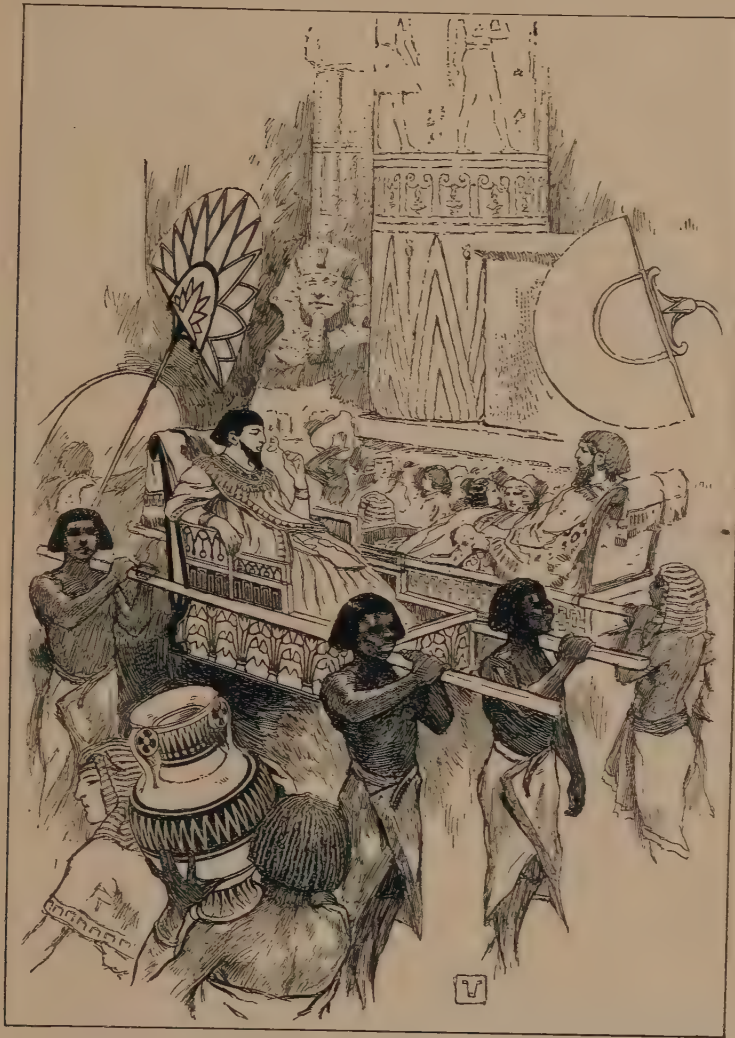
SAVAGES LOOKING INTO A POOL OF WATER—NATURE'S MIRROR.

neat. His dress is a long fluted robe of fine white linen, and he is adorned with necklaces, bracelets, and a multitude of finger-rings. Altogether he is quite a dandy.

This dress, with only a few changes, continued for many centuries to be the dress of Egypt, and also of the other nations that began to flourish in the Orient—of Chaldea, Babylonia, Judea, and Assyria. Like the Chinese who let their fingernails grow into long slender claws to show they

do no manual labor, so these old Babylonians and Assyrians used to show their rank by the length of their skirts. The rich and leisurely wore

the cavalryman had to have some sort of a uniform, and it was impossible for him to wear a skirt and ride astride a horse. The tailors to his



"THE EGYPTIAN GENTLEMAN CARRIED IN A PALANQUIN THROUGH THE STREETS OF THEBES."

skirts that trailed on the ground; the laboring classes, who while at work would be constantly tripping over long skirts, wore a short kilt that reached scarcely to the knee. Of course these short skirts made poor clothing according to our modern ideas; but in these Eastern countries, with their clear sky and balmy atmosphere, clothing is little needed, and customs are different.

In the reign of the Assyrian king Asshurizirpal (883-858 B.C.) horses were introduced into the army as cavalry. Here, now, was a problem:

Majesty's armies wagged their heads a long time over this problem, and finally decided that the only way out of the difficulty was to cut the cavalryman's skirt from hem to waistband in both front and rear, letting each part fall on its respective side of the horse. As can readily be imagined, this split skirt made an exceedingly poor article of clothing. The law of heredity, however, is full of surprises; this humble apology for a garment was destined to be the father of the original pantaloons.

The tailor has long been a subject of jest. It is likely that even then, as now, it took "nine tailors to make a man." At any rate, it took the tailors of Assyria over a century to solve the problem of the horsemen's clothing. "Why not," said one of these workers with the needle and shears, "sew together the edges of each division of the skirt and thus form a separate skirt for each leg?"—or, in other words, he invented a *pair of pantaloons*.

It would seem that the advantages of this newly invented garment should have been immediately recognized—that the entire male populace of Assyria should have greeted it as a welcome release from the thralldom of skirts. But the first representative of the trousers family received no such welcome. Only the cavalymen adopted the new dress, and the other men continued to wear the skirt in all its varied lengths, and with all its awkwardness.

Toward the beginning of the seventh century B.C., the Assyrians seem to have become wiser. The short knee-skirt of the workman went out of fashion; all those of whom active service was required adopted the easy and serviceable pantaloons; while the rich snobbishly retained the cumbersome long skirt.

This remained the dress of all the people living in what is now known as the Orient, until the Persians introduced a new style of trousers, that were loose and baggy and gathered at the ankles. These loose and flowing trousers soon became very popular with the people of this warm climate, on account of their lightness and airiness; and through all the succeeding centuries they have remained the standard dress of this region, and they are worn to-day by the present occupants of the land, be they Turks, Armenians, Persians, Arabians, or what not.

While we have been following the trousers' history in the Orient, new nations have been springing up along the northern shores of the Mediterranean. Greece and Rome meanwhile have both become great, powerful nations. But in Greece trousers never got a foothold. The men and women dressed almost alike. A large, square piece of cloth, known as the "himation," was wrapped around the figure, leaving only the right arm free. If the family treasury had run low, the same outer garment often served for both husband and wife; and it was gossiped about Athens that one of the causes of the matrimonial troubles between Socrates and his wife Xanthippe was that Xanthippe refused to go out in her husband's himation—she believed in woman's rights, and wanted a himation of her own! The Romans copied their dress from the Greeks,

so there was little difference, except that when the Roman armies began to push northward, and were exposed to the rigors of a northern climate, the soldiers adopted, in conjunction with their tunics, tight-fitting trousers that reached to the



AN ASSYRIAN WARRIOR.



THE EARLIEST TROUSERS.

calf of the leg. These were copied from the trousers worn by the sailors of the ships lying in the Tiber, ships that had come from Phenicia, at that time the great merchant nation of the Orient.

In their commercial dealings these Phenician traders were carrying the arts and inventions of the East to other lands than Rome. Besides trading with several rich African nations, they were carrying on a barter with a race of painted wild men who inhabited a remote group of islands in the Atlantic Ocean—a group of islands that afterward became known as the British Isles. It was for the tin with which this barbarous land seemed to abound that the Phenicians risked the long, dangerous voyage into unknown seas, carrying with them, for exchange with the native Britons, many bright-colored cloths, beads, knives, and other things that delight the savage heart.

These dealings with the traders, together with an invasion of the islands by a Roman army under Cæsar in the year 55 B.C., started the British barbarians on the road that leads to civilization. Among other things, they learned the art of weaving; and then they began to stop painting their bodies, and adopted a dress which was a rough copy of the style worn by the traders—a close, tunic-like coat, and short, loose pantaloons. We now see the family of trouser garments started on its long and tumultuous career in the British Islands—a family that is long-lived

and venerable, and yet is absolutely without stability—gay and extravagant when the times are gallant, stiff and prim when festivity is frowned upon, and dignified and stately when the times are aristocratic and courtly, like a delicate weather-vane whirling around with every change in the social atmosphere.

About a century after the first invasion, England was again conquered by the Romans. One after another, the various hill tribes were subdued; Britain gradually became Romanized; and the coat and pantaloons of the natives were discarded for the tunic and mantle of Rome. This is perhaps the only instance in the history of the world where a trousered people have become an untrousered people. But it was not for long. The classic dress of Rome soon proved unsuited to the inclement weather of Britain, and the people began to drift back to the old way of dressing. Within a very few generations, the only trace that was left of the Roman style was a long tunic, reaching below the knee, which the Britons had retained in imitation of the long, flowing toga of Rome.

Meanwhile English industries had been growing. By the beginning of the eighth century London had become a city of some little commercial importance. Great quantities of wool were sent abroad, and, in exchange, the trading-ships brought back the silks and fine linens of

than a century or two. During the eleventh century a great horde of Normans under William the Conqueror poured into Britain, and in a few years subdued the country from end to end. The new masters of the land were people of luxurious tastes; and as a conquered people had to "pay the piper," the conquerors gave free reign to their extravagant inclinations. Soft and delicate stuffs trimmed with expensive furs were worn, together with many glittering jewels. The cut of the dress, however, remained about the same, except that the Norman noble, wishing to make a marked difference between his own costume and that of the British serf, extended his tunic until it swept the ground, and lengthened his sleeves until they became so long that when walking he had to tie them up in knots to keep them out of his way. This idea, that the best way to assert one's dignity is to wear a long gown, is a notion deeply rooted in the human mind. We have already seen that the old patricians of Assyria and Babylonia wore trailing skirts to show they were no common people. The Roman senators used the long, flowing toga as the insignia of their high office. All through history kings have played their little parts in royal robes of state. Even in these early years of the twentieth century, priests and ministers wear variously designed gowns as symbols of the dignity of their positions; and so also do the judges of some of our higher courts. Even our college boys, in their senior year, assert their superiority over their lower-classmen by donning long black gowns and mortar-boards.

After living on the fat of the land under the iniquitous feudal system for about a century, the Norman line of kings was ousted by Henry II., who invaded England from France. Hardly had Henry got comfortably seated on the throne when those troubles broke out which kept the British kingdom in a constant turmoil during the reigns of Henry and his seven successors of the Plantagenet line. It was about this time that the common people began to awaken to the fact that they were not born merely to feed a greedy and luxurious nobility; and that long and bitter struggle was begun that finally resulted in the granting of the "Great Charter." The crusades to drive the infidels from the Holy Land, and recover the tomb of the Saviour, were also commenced during this period. Then the members of the royal family were squabbling among themselves; the nobles were at swords' points, not only with one another, but also with the king himself; and to add to the general hurly-burly, France and several other foreign states were on the constant watch to give assistance to every plot or rebellion that was



TROUSERS AS WORN
IN THE EAST.

ROMAN SOLDIER, WITH
SHORT TROUSERS.

Normandy and Flanders. The nobility, growing rich on the revenues, began to have their clothes made of fine stuffs.

But the British nobles were not allowed to enjoy their riches and their fine clothes for more

started in the little kingdom across the Channel. During this fighting period every man who was capable of drawing a broadsword, and who was not a yeoman, went about incased from head to foot in stout armor. Some dress had now to be designed that could be worn comfortably under this metal sheathing. The result was the adoption of a short coat and tight-fitting pantaloons that reached from the waist to the ankles. This looks like a plain and simple dress; but if we could peek into one of the court levees of this period, we would see, when the knight lays aside his hot and heavy armor to join the festivities, that he has gratified his love of finery by having his clothes made of the finest silks and linens, and of the most startling colors. His coat is of one color, his sleeves of another, and his pantaloons of still another. Sometimes he has one leg of his pantaloons green and the other red. And on top of this, he cross-garters himself with ribbons of still other colors. This patchwork suit may seem very foolish to us, but we should not expect much sartorial sense from a people who were accustomed to wear nightcaps but no nightgowns.

Events in history often bring about very strange results. Thus the bloody and disastrous crusades that England waged against the infidels in the Holy Land, during the twelfth and thirteenth centuries, resulted in the introduction of many gay and giddy styles into British dress. In their long marches across Europe the crusaders had become acquainted with many odd styles of dress, and in the Holy Land they had learned to love the dazzling splendor of the Oriental silks and velvets. The result was that when the knight returned from the wars and put off his armor, he became a fop. To be gay and striking was the

aim of every man of fashion. The dress that by its gaudiness finally gained the popular approval was one composed of an immense series of puffs and slashes. Through these slashes shone brilliant silks of many different colors. This fantastic dress, however, had one merit: it introduced a new style of trousers. The innovation consisted in the trousers ending at the knee, the legs from the knee down being incased in a separate article of clothing that became known as "stockings." When we look at these elaborate costumes made of costly stuffs, we may wonder how the nobles could have afforded them; but, as a wise man has remarked (though I won't say how authentically), "Those were indeed the good old times: whenever a knight saw his creditors approaching he simply pulled up his drawbridge."

While the barons and their military retainers had been exterminating each other on the field of battle, the merchants and craftsmen had been steadily at work piling up the golden ducats, so that by the beginning of the sixteenth century they formed a large and influential part of the country's population. All that they wanted was a period of peace in which they could comfortably spend and enjoy their wealth. Bluff King Hal, who succeeded to the throne about this time, was a jolly monarch with no love for strife, and just the kind of a king the people wanted. The wars were now ended for a time, and a merry, busy, bustling time ensued. Good cheer prevailed throughout the kingdom, and beef and strong ale were abundant on every man's table. This conviviality and high living soon made the men as round and fat as the beer-barrels in their cellars. But not content with their own portly magnitude, they puffed out their trunk-hose to such an ex-



IN THE DAYS OF DOUBLET AND HOSE,

tent that one contemporary wit said of them: "They are almost capable of a bushel of wheat, and if they be of sackcloth they would serve to carry malt to the mill."

A half century later these merry times were brought to an untimely end by the accession to the throne of Bloody Mary. The cherished object of this monarch was to make her own religion supreme in England. A terrible persecution ensued. Over two hundred and seventy-five persons suffered death at the stake. In the face of

sumed. The cardinal of the realm had in his household over five hundred persons. Magnificent dress was the natural accompaniment of this style of living. A gentleman's clothes were made of rich satins and velvets of divers hues. His sleeves were puffed out until the shape of his arm was entirely hidden; his doublet was stuffed from the shoulders down to the waist; and his trunk-hose were enormously padded from the thigh to the knee; this whole suit being elaborately slashed so as to show the rich linings beneath. That glory of the Elizabethan days—the starched ruff—gave the finishing touch to a costume that was already so stiff and padded that if a knight were unfortunate enough to drop his hat or his cane, he had to call for a servant to pick it up for him.

These monstrously puffed clothes became even greater in size during the reign of the following monarch, for James I., being a timid king and fearful of assassination, looked with great favor upon these padded clothes as a defense against the dirk or stiletto. To extend these clothes to this preposterous size, rags, wool, hair, and bran were used, until an embarrassing accident befell



THE CAVALIER.

THE DUTCH COSTUME.

such barbarities, merry-making went out of fashion. The people became grave and apprehensive; and no wonder, for no man knew but what it would be his turn next. The brilliantly colored puffed suits disappeared, and in their place was worn a somber-colored suit consisting of a short tunic and small trunk-hose.

When this misguided monarch fell ill of a lingering fever, it is very doubtful if there was much grieving among her subjects; at any rate, when she at last died, the people joyfully welcomed the accession of the new monarch. When Queen Elizabeth took up the reigns of government, happiness and prosperity once more spread throughout the kingdom. It was in these days that England's trade, led by those renowned voyagers, Sir Walter Raleigh and Sir Francis Drake, began to stretch to the remotest corners of the globe. Money flowed into Britain's coffers, and the Britishers spent it freely. The nobility maintained large retinues of knights, squires, household retainers, and servants, and entertained royally every day. At an entertainment given the queen by the Earl of Leicester, the most astonishing prodigality was displayed. Among other sumptuous details, it was reported that three hundred and sixty-five hogsheads of beer were con-



THE ROUNDHEAD.

IN QUEEN ANNE'S REIGN.

a certain prominent lord of the realm. Arising from his bench to address a crowded House of Lords, a projecting nail tore a hole in his trunk-hose. With a proud bearing suitable to his lordly dignity, he strutted to the front of the chamber to make his speech, the bran meanwhile pouring through the tear in his hose. The assembly broke into a roar of laughter.

Discovering the catastrophe that had befallen him, the speaker instantly lost his lordly bearing, and turning, ran for the door, his shriveled hose

flapping about his legs. After this, a wire apparatus like women's skirt-hoops was used to extend the hose.

To such an excess was this full-blown style of clothes carried that all of a sudden it burst. From pads and ruffs and wire frames, fashion suddenly veered around to a simple, easy, and graceful style. It was no longer the ambition of a gentleman to appear as fat and burly as padding and



FRENCH REVOLUTIONARY.



GEORGIAN.

stiffening could make him. It was now his object to be slim, graceful, and elegant. His dress became a close-fitting doublet, petticoat-breeches, boots with wide, flapping tops, and a short cape. This suit was tastefully ornamented with delicate lace and embroidery. Altogether this is considered the best era of dress in England.

But, unfortunately, there soon began to grow throughout the kingdom those troubles which finally ended in the civil war of the Covenanters. England divided itself into two great factions: on the one side were the Cavaliers, who supported King Charles in his effort to run both the state and the church according to his own sweet will; and on the other side were the Roundheads, who were fighting for a free Parliament and the right to worship in their churches as they saw fit. So fierce and high did party feeling run that no marriages or even commercial dealings of any kind were permitted to take place between the members of the hostile factions. While these Roundheads were men fighting for a good cause, yet they were of a gloomy temperament, with a faith of such rigid severity that it permitted no recreations except such as were to be gotten out of hymn-singing and psalmistry. The Cavaliers

were generally men of birth and fortune, and were gay and free in their manner. These temperaments were reflected in their clothes. The austere Roundhead, under his stiff, broad-brimmed, steeple-crowned hat, wore his hair closely cropped. His clothes were made of some somber-colored cloth, and both his doublet and his hose were as plain and simple as his wife or his mother could cut them. There were no laces or jewels or ribbons about him; it is even said that he wore his hat without a hatband. The Cavalier, partly from taste and partly to ridicule the excessively somber dress of the Roundhead, dressed himself in the most elaborate and foppish style. He wore a shirt of the finest linen, trimmed with lace, a soft silk doublet, a broad point-lace collar, short breeches ornamented with fringe and bunches of ribbons of several colors on either side, and boots with broad, flapping tops trimmed with ruffles of lace. This exquisite wore feathers in his hair and patches on his face, and had his hair tied with ribbons into love-locks. Even the lily of the field, in all its proverbial glory, could not equal one of these.

But, like spring lilies before a belated snow-storm, these dandies entirely disappeared during the severe Commonwealth which the Roundheads finally succeeded in establishing. When, however, the Commonwealth fell, and Charles II. was restored to his throne, they blossomed forth again in all their first glory.

Toward the close of the seventeenth century,



FIFTY YEARS AGO—AND TO-DAY.

the old line of kings was supplanted by a sovereign whom the English imported from Holland

to govern them. King William brought with him from his native land the Dutch fashion of dress—plain, dignified, and picturesque; and as Englishmen just then had something more important than the style of their dress to think about, this simple costume was adopted throughout the land.

The Dutch fashion of dress, however, had not been many years resident in England before the tailors and the hatters and the haberdashers, by putting a touch here and another touch there, gradually made an entirely new fashion of it. The broad-brimmed hat became doubled up into the cocked hat; the long hair was supplanted by the powdered wig; the square-cut coat and waistcoat became finely embroidered; the loose, baggy breeches were narrowed down to close-fitting knee-breeches; and the plain woolen hose were changed for delicately colored silk stockings. It was in this costume that Beau Nash, perhaps better known as the "King of Bath," and his many imitators disported themselves. To any man of fashion dressing was an important matter that received daily at least several hours of serious and undivided attention. The beaux even had a club where they met to compare costumes, and to decide whether a blue or a claret or a brown coat should be the "proper thing" for the coming season.

About the end of the eighteenth century, a tremendous social upheaval, the French Revolution, shook Europe from end to end. After patiently bearing for centuries the wicked burden of a corrupt and extravagant upper class and a pompous and idle clergy, the people seemed suddenly to realize their power. "How is all this pomp supported?" they asked of each other. "Out of the sweat of the people!" was wrathfully answered. And then "the five-and-twenty savage millions, amid smoke as of Tophet, confusion as of Babel, noise as of the crack of doom," fell upon every one and everything that represented or stood for the old system of injustice and serfdom. In their relentless fury, nothing was spared; men and women alike were carried by shouting mobs to the guillotine. Even the little dauphin, a lad of eight, was thrust into a foul prison, where "for more than a year he had no change of shirt or stockings," and where he at last died from neglect and suffering. In fear and trembling at the power of the people, the

aristocrats threw away their silken knee-breeches and powdered wigs, and put on unpretentious clothes. "'Don't kill us,' they cried; 'we are the same as you; do we not dress alike? Are not our clothes as simple as yours?'" Men now wore their own hair, short, plain, and unpowdered. The wide skirts of the coats were cut down to long tails, and the knee-breeches were lengthened to the ankle, and became pantaloons.

It was a noisy farewell that the world gave to the frippery of the passing century. After that wild burst of savage spirits, it settled down in a fairly quiet way to do the work of the busy nineteenth century. As time has passed, clothes—at least men's clothes—have become more and more somber in both cut and color.

At the present day their costume has been reduced to something like a uniform. To business a man wears a cutaway or sack suit, and in the evening a black long-tailed coat with a low-cut waistcoat. The length of his coat-tails and the cut of his waistcoat are both dictated by fashion, and every man's clothes are now very much like his neighbors'.

Of course, we have become used to our clothes, and our vanity makes us think that they are the most artistic and sensible that the world has yet seen. But every age has thought the same thing. While we may laugh at the men of the fifteenth and sixteenth centuries in their wonderfully puffed clothes, it is very likely that if they could rise up out of their graves they would have an equally good laugh at us. "What is the matter?" they would ask. "Have you had some great national calamity, that all your men should be dressed in dismal black, like a lot of mourners? And that box that you wear on your heads and call a high hat—surely that must be very hot and uncomfortable? But your trousers"—and here these old-timers would burst into a merry ha-ha—"why, they are the worst of all; they make your legs look like sawed-off posts!"

Some one has said that when the archeologists of the future dig up one of our bronze statues in trousers, they will have no need to go further to find what a rusty age this has been. But what style of trousers will these future archeologists be wearing? That, alas! is asking a question that Father Time, in his mysterious flight, alone can answer.





I. A ROYAL FAMILY

DOWN the grand staircase, tripping lightly, with her finger on her rosy lips, her curls flying, the tail of her satin gown over her arm, came "Mistress Mary, quite contrary," of the royal house of Tudor, closely followed by her attendants.

The day was young, and "Brother Hal" was asleep, so Mary felt care-free as she danced across the polished floor and out through the great door of the palace. The garden was drenched with the morning dew, but the little satin shoes plunged recklessly through the dampness, in and out among the flower-beds of the king's garden, plucking here and there as fancy craved, with no thought of consequences. There were few who dared to pluck the king's flowers, but Henry VIII., with his testy temper, had a genuine affection for his youngest sister, and was only "Brother Hal" to this madcap princess. He was "bluff King Hal" in those early days, living peacefully enough with his good wife Catharine and their little daughter Mary, and the court would have been a dull place indeed had not the king's sister played her pranks and kept them all astir.

Only a girl she was—twelve or thirteen at the most—with all the freshness of the springtime in her blood; but they dressed her like a woman, for she was tall and well built, having beauty, too, and a sharp and ready wit. This morning she led her companions a wild chase from terrace to terrace, in among the flower-beds, gay with yellow and white narcissus and deep-hued pansies, sweet with violets and jasmine.

"Pluck them, pluck them!" she cried to the others, and while they still held back, she stamped her little foot, and the hot blood of the Tudors

flamed in her cheeks. "Mary Tudor commands!" she said, with an imperious wave of her hand.

"But—your Highness—the king—" began a timid damsel.

"Out upon you, Jane! Come hither, gentlemen; stand round and hide the timid wench from view while she does my bidding. Tush! child, the king will not miss them, but should he do so and call you to account, why then, forsooth, *I* commanded you to take them!" She flung her head with royal scorn, showing the bare rounded throat from which the soft ruff fell back.

"On, on, my lords and ladies, to the tennis-court!" she cried, and these children—they were nothing more—followed their daring young leader to the king's beautiful courts. Tennis was the popular game of the day; indeed, there are few games played with a ball which can boast of such antiquity, but it was a game for kings alone, or for those very high in rank, so we can imagine Mistress Mary, her gown tucked up, her eyes sparkling, her curls flying, her strong, lithe young figure darting swallow-like after the ball, her racket poised to send it back across the net.

This first girl who wore a ruff was very like other girls of her age. Our grandmothers perhaps would have called her "forward and pert," but poor little Mary had no mother to check the wild spirits and curb the very strong will.

A few years later, in the train which had accompanied Mary to France, where she married the French king, were Sir Thomas Boleyn and his little daughter Anne. This small maid, barely more than a child, had become such a favorite at the French court that she did not return to England with the young Queen Mary when the old king died. She grew to be a most bewitching

little creature, full of grace and joyousness, but fond of admiration and power above all else. She received enough compliments and flattery to have turned her silly head, so it was high time her father brought her home to their country-seat, whence an occasional visit to London Town was a rare and wondrous dissipation. A letter which she wrote to her sister during one of these visits shows her to have been, at heart, a very simple girl. It reads:

DEAR MARY: I have been in town almost a month, yet I cannot say I have found anything in London extremely agreeable. We rise so late in the morning—seldom before six o'clock—and sit up so late at night, being scarcely in bed before ten, that I am quite sick of it, and were it not for the abundance of fine things I am every day getting, I should be impatient of returning into the country.

After describing some of the "fine things" bought by her "indulgent Mother," she adds:

And I am to have a pair of new stuff shoes for my Lord of Norfolk's ball, which will be three shillings. Pray take care of the poultry during my absence. Poor things! I always fed them myself; and if Margery has knitted me the crimson worsted mittens, I should be glad if they were sent up the first opportunity.

In truth, there was plain living for the children of that day; breakfast at six and bedtime at ten were considered fashionable hours even for the "grown-ups." Practical little maids these were, with their poultry-yards and their dairies, counting the pennies much more carefully than the girls of to-day, in spite of the routs and balls and gorgeousness of the court; and crimson worsted mittens were a great comfort in cold, bleak London.

History does not record whether Anne Boleyn wore a ruff before her marriage to the king, but she chanced to be the mother of the lady who wore the biggest ever made. For, by Elizabeth's time, they had become quite the fashion both with men and women, young and old.

II. LIFE AT HOME

To the girls of to-day, whose lives are governed by kindness, whose homes are to them the centers of happiness, the lives of the maidens of the Middle Ages must seem very dreary. Parents had an idea that sternness was the only rule by which to bring up children, and if they failed in that they were not doing their duty. Even big boys and girls stood silent and uncovered in their fathers' presence, and girls knelt humbly on a cushion until their mothers had left the room. The instant children offended their parents, they were punished with stripes and blows.

But, of course, in fair England there must have been some happy youngsters whose fathers and mothers were not always thinking of their faults. On the banks of the Thames, in beautiful Chelsea, about a hundred yards from the waterside, stood a fine English homestead, built after the fashion of the times, with overhanging porches and bay-windows, jutting casements and gables, and furnished with all the comforts to be obtained. Here lived the finest statesman and most noble gentleman of King Henry's reign, Sir Thomas More, with his wife and children. There were three fair young daughters, Margaret, Elizabeth, and Cecily, a son John, a stepdaughter also named Margaret, and an adopted daughter—another Margaret still. Margaret More was always called Meg, her stepsister Daisy, and Margaret Giggs, the adopted daughter, was distinguished by the name of Mercy.

They all grew up in this lovely country home and worked and played and studied happily enough. The More girls read and wrote Latin quite as easily as English, and cultivated their minds as well as their healthy young bodies, for they were out in the open all the time they were not at their books or helping in the house, and their wise father took care that they did not become overlearned little prigs. In spite of Plato and Socrates, they could enjoy a pull on the river, a supper by moonlight, an evening in the hay-field, full of pleasant talk and laughter and harmless jests. They were fond of animals of all kinds; dormice, owls, and hares were some of their pets, which they tamed and trained to do all sorts of tricks.

In the house there was much work for each little maid. They rose even before that famous bird, the lark, and though their stepmother was generally very good to them, she set them hard tasks. On one occasion something went wrong with the churning, the butter would not come, and the household was quite upset. Good Dame Alice flew around distracted, and Gillian, the cook, declared the cream was bewitched. Every misfortune in those days was laid to witchery, not only among the common people, but among many of the higher class; but Dame Alice More knew better. The churn was filled with good cream which could not be wasted, so she sent for the four older girls and bade them take turns at the churning till the butter came, if they sat up all night for it. Other girls might have complained, for it was late already, but they went to work with a will and beguiled the time by singing "Chevy Chase" and other frolicsome tunes, but still the butter would not come. At length Mercy suggested that they chant the One Hundred and



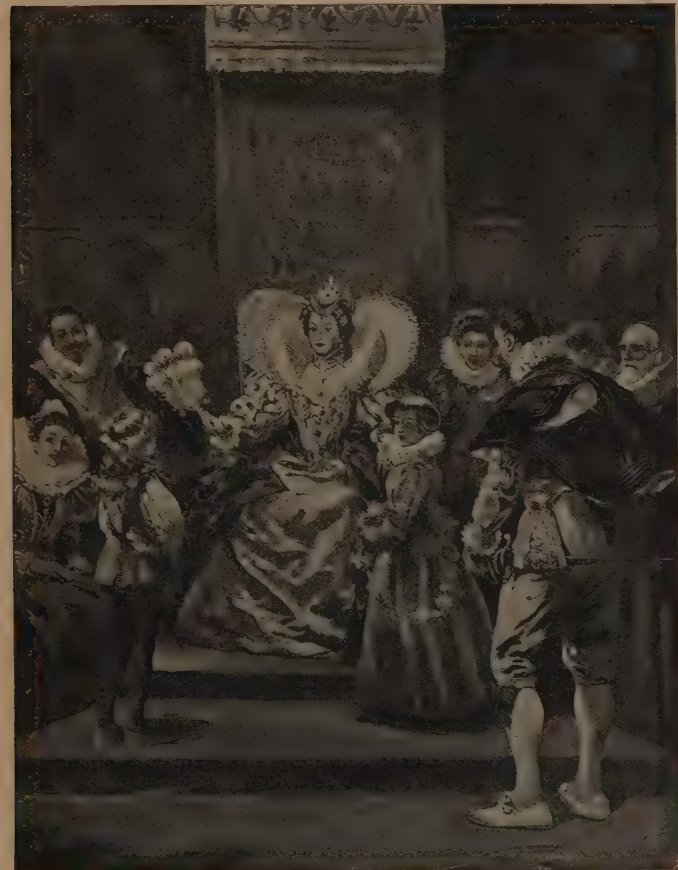
WHEN THE RUFF WAS WORN.

Nineteenth Psalm, which they did in Latin, and presently they heard the buttermilk separating and splashing in earnest. It was near midnight and they were almost asleep before the butter came, but Gillian was convinced that their Latin broke the spell.

The little maids went to court with their mother, Dame Alice, who was resplendent in

apart, playing cards, or chess, or "tables," which we know better by the name of backgammon.

Meanwhile the ruff began to increase in size, and after King Henry's death it became a general article of dress. Little King Edward VI. drew around him many small lords and ladies, for even while Edward was still a boy, his uncle, the Lord Protector, was hunting for a Queen of England, and many a tiny lass in all her bravery came to court to make her bow and pass muster there. Among his favorite playmates were his cousin Lady Jane Grey and his big sister Elizabeth; his elder sister Mary was too old and grave to be much of a companion.



"IN THE DAYS OF 'GOOD QUEEN BESS.'"

crimson gown and coif, the girls in satin petticoats puffed high in panniers over their slender waists. Tight-laced corsets were then fashionable; over these, the square-cut bodices, with the upstanding ruffs of lace richly embroidered in gold and silver; sometimes little caps upon their heads, but oftener their curls escaped and lay in ringlets on their white necks. We have seen them, or at least girls like them, in pictures which good Master Holbein has left behind him.

The king made merry at his court, and many games were played to pass the time. Dancing was much indulged in, the young ones joining in the stately measures, while the older ones sat

The burly, wicked King Henry had done one good thing—he taught his subjects the use of learning. The very smallest girl of any rank at all could read and write good English, and, better still, good Latin, with often wide knowledge of Greek. Most famous among the girl scholars was Lady Jane Grey. She was a granddaughter of the madcap Princess Mary, and so closely connected with the throne of England that a marriage with the young king seemed a wise and proper thing. Henry VIII. had another grandniece, little Queen Mary of Scotland, granddaughter of his older sister Margaret, who would also have made a fair Queen of England. Both these girls were great students and rivaled their cousin Elizabeth in cleverness and learning. Mary never saw her English cousins, but doubtless Jane and Elizabeth must have been closely associated, for Elizabeth's tutor, Roger Ascham, knew the small Jane

quite well and often praised her learning. And Elizabeth, during her childhood, was at best but a poor, unnoticed princess, neglected at court and in many instances severely treated. History may not make mention of so slight a thing as an interchange of girlish confidences, but it is pleasant to picture these girls with the ruffs wandering in the old gardens or pacing a long avenue shaded by great trees.

But the ruffs were growing fuller and taller. The girls could not put their heads together and whisper secrets; they could not even sit close together, for the fashions were putting them far apart, behind a mere masquerade of dress.

III. LIFE AT COURT

WHEN Elizabeth was queen, things had come to a pretty pass. The real girl, from her slim waist down to her toes, carried a framework on which she hung her garments; she wore long, straight, tight corsets, stiff with whalebone, and when the corsets were laced up, and the framework hung



QUEEN ELIZABETH.

from her waist, my little lady then put on her farthingale. This was a round petticoat made of canvas or cloth stiffened with whalebone and covered with taffeta, or some other good material, so broad just below the waist that its circumference was greater than round the bottom of the skirt, something like those severe ladies in a toy Noah's ark, only bigger. The slim girlish figures looked pinched and narrow, between the wide hips, the puffed sleeves, and the standing-out ruffs.

Though modest at first, these ruffs became a most imposing structure. Of course they were made for people who had long necks, like Elizabeth and Henry III. of France, and Marguerite de Valois, Queen of Navarre, another long-necked lady; and as girls became "grown-ups" and even "married dames" when they were scarce in their teens, of course they must needs follow the fashion in the matter of ruffs. Well, they grew and grew, those ruffs, but only the higher class could afford to wear them, for starch had not yet been heard of, and one or two wearings

made them hang limp about the neck. King Henry of France, who was tall and thin, with a very long neck, wore a ruff one third of a yard deep, containing about eighteen or nineteen yards of linen. Indeed, in the French court, the lords and ladies could scarcely move their heads and found it extremely difficult to eat and drink.

Many of these ruffs were made with four or five rows of lace, the last row appearing above the top of the head, and each supported by threads of wire. The ruffs put an end to flowing hair. It was piled high on the head and in many cases worn in short tight curls; ladies used false hair in great quantities and changed the color whenever they pleased. Elizabeth is said to have had many wigs of various colors. Strings of precious stones were twined in the hair, making quite a pretty head-dress. So popular did wigs become that there was scarcely enough hair to supply them, and the small maid with long locks never went out alone, for fear some unscrupulous person might cut them off and sell them.

English people did not wear their ruffs quite so wide, a quarter of a yard being the limit, and pretty young girls took care to set them well back from the neck, to show their white throats. The queen's ruff was extraordinarily high and stiff. But even the well-to-do did not like to see their pretty ruffs hang limp, and thanks to the wit of a certain clever woman, the remedy was found.

In the year 1564, Mrs. Dinghen, the wife of Elizabeth's Dutch coachman, brought over to England the art of starching. Imagine the delight of the courtiers when ruffs were taught to "stand alone," and possibly the poor little girls rejoiced more than all, for they were not continually having their ruffs "pinched up" whenever they came near the ruthless hands of their elders. Mrs. Dinghen soon became court starcher and established a fine business. All the great ladies in London sent their crumpled ruffs to be "done up," and the good woman starched them white or yellow to order. Many came to her as pupils, and honest Mrs. Dinghen bade fair to become a very rich person.

Besides the starch, wires were often used to stiffen the larger ruffs. These wires, covered with gold or silver thread, came round the neck as a sort of support, for the mass of linen was very heavy. Many of the ruffs, too, were worked with silk embroidery and tinsel threads.

IV. DAYS OF SPLENDOR

IN the days of "Good Queen Bess" court life took on a splendor that it had not known for years. Elizabeth loved magnificence, and the lords and



Costumes (3) from the 17th to the 19th Centuries.—*Upper line from left to right:* Charles I. of England (1624), French noblewoman (1650), Dutch couple (1640), English noblewoman (1640), nobleman (period of Thirty Years' War), and lady of Cologne's citizen class (1633). *Lower line:* Louis XIV. (1680), French noblewoman (1680-1700), lady and gentleman of 1730-40, Frenchwoman (1794), French dandy (1795-99), French gentleman and lady of the Empire (1803), the latter in Greek dress.



GREEK FEMALE DRESS

ladies of her court dressed and lived with a sumptuousness never before heard of. The girls who wore ruffs were in many instances among the queen's ladies-in-waiting, for, being the "Virgin Queen," she had many maids about her, and kept up a vigorous correspondence with her "dear cousins" this or that, at home or abroad, for Elizabeth was a clever letter-writer. Her dear cousin Mary Queen of Scots was perhaps the "dearest cousin" of all; indeed, many and most affectionate were the letters exchanged between the two queens who hated each other with such deadly hatred.

These girls who wore ruffs began to have more comfort in their living, more pleasures in their daily intercourse. Their homes were very beautiful, but articles of furniture in those days were very rude and defective. Down-stairs, in the halls and banqueting-rooms, one came across fine tapestries, richly carved woodwork, massive tables, besides much fine plate and gilding; but above-stairs my lady's chamber was simple and severe—a cupboard or two to accommodate the stiff gowns, a jointed stool, a steel mirror, a ewer and basin for her toilet, a plain table for her books, perhaps an embroidery-frame, and a stiff high-backed chair. The bed alone was luxurious; it was canopied and festooned like a throne, of softest down, with fine blankets, linen sheets, and a coverlet embroidered with the arms of the owner, and over all were beautiful silk hangings.

A girl had a great deal to do in those days. She could always play upon either the lute or the viol. She commenced her morning—usually in the gray dawn—with prayer; then a hearty breakfast of meat and ale; next there was embroidery to do, after which she visited the dairy and the pastry-cook; later she worked in her garden; then a visit to her bees, or to see if the hemp was coming up, or to inspect the cows, or to feed her poultry in the farm-yard. At court the maids-in-waiting avoided idleness by using their needles, reading the Bible or history, or by writing; they also studied music when off duty.

Shuttlecock was a great favorite among girls, for there were spacious halls in which to play, and tennis became more common. Blindman's-buff, or hoodman-blind, as it was then called, was popular among girls and boys, and a dozen other games which are played and enjoyed by the children of to-day. But most they loved the open. Every little maid of any degree could mount a horse, some could even join the hunt, and many of the rollicking songs of the times caught their childish fancy.

There were festivals, too—Christmas with its mummeries, May-day with its pole and dances,

Shrove Tuesday, and all the others. There were fairs held on the village green, and many pageants to delight the eye, for Elizabeth journeyed from place to place with splendor and ceremony, and little country girls, dressed in their best, stood in the highroads to curtsy as she passed.

Away in her quiet country home, small Amy Robsart heard with wonder of the doings of the court; the far-off splendor caught her girlish fancy. Her mother died when she was a baby,



MARY QUEEN OF SCOTS AT THE AGE OF TWELVE.

and her father, Sir Hugh, petted and spoiled her, denying her nothing it was in his power to give. She was a beautiful little creature, and she longed to get out of her tiny corner of the world. She could not have been more than fifteen when the gorgeous, glittering Leicester found out who she was, and wooed and won her.

The little countess, as we all know, lived the rest of her short life at Cumnor Hall, very near the earl's great castle of Kenilworth, the scene of the most wonderful feasting and pageantry ever displayed in England. Dear little Amy! so trusting and childlike, yet so womanly withal. Did ever a fairer maiden wear a ruff? Even Elizabeth was moved by the quiet grace of her, and my Lord of Leicester got the cold shoulder when the news of her death broke up their revels at the castle.

But of all the girls who wore ruffs, there was none sweeter and fairer than Mary, Queen of Scotland. She was the tiniest wisp of a baby when her father left her queen of this cold, bleak country. On her nurse's knee she gazed with round eyes on the peers of the realm who knelt in homage before her. She was only nine months old when she was crowned in Stirling church; she was taken from her cradle, wrapped in royal robes, and carried by her lord keepers and officers of state to the ceremony, and because poor Baby cried for her nurse, it was considered an ill omen. From the moment of her birth her great-uncle, Henry VIII. of England, tried to kidnap her, for, besides being Queen of the Scots, she was along the line of succession to the throne of England, and there is no telling what the old monster would have done to her had she fallen into his clutches. But her faithful lord keepers kept guard, and the baby was allowed to see but one noble at a time, and no visitor could enter Stirling Castle—which was her first home—with more than two servants in his train.

When she was about four, they sent her for greater safety to the priory on the Isle of Inchmahom, in the beautiful Lake of Menteith, famous for its Spanish chestnut-trees. They formed a merry party in the grim old priory. The little queen was allowed to have with her her four young namesakes and playmates, Mary Beaton, Mary Seaton, Mary Livingston, and Mary Fleming—the queen's Maries, as they were called. What happy times they had, those five, along the shores of the lake, the little queen in Highland costume, her golden hair bound with a rose-colored snood, her tartan scarf fastened with a golden agraffe engraved with the united arms of Scotland and Lorraine. She was French on her mother's side and closely related to the reigning house. When she was six, a charming, gracious little princess, it was arranged that she should marry her cousin, the Dauphin of France, as soon as both children were old enough, and it was decided that she should go to France to complete her education, which was far advanced for a child of her age. She compared favorably with all the girls of her day in her love of learning.

There was no happier, merrier, sweeter, more lovable little girl; she excelled in the dance; she inherited from both parents a love of music and great delight in poetry; she was fond of sport and astonished every one by her skill in handling her falcon. Nothing pleased Mary more than the preparations for a mighty chase. What a brilliant portrait of a girl she makes, and how we love to look at it and to think about it!

With the passing of "Good Queen Bess" much

magnificence vanished from the court; but the ruff stayed on, not so deep nor so full, but a most important part of the dress for all that, and much more comfortable. Master Will Shakespeare wore it, and his daughter, pretty Judith, the belle of Stratford, the daintiest maid in all Warwickshire, wore it, too, with her Sunday kirtle. She was a merry little lass, and one of our English novelists has painted a fair picture of her as she walked in the quaint old town along by the church and over the foot-bridge spanning the Avon, and so into the meadows lying adjacent to



POCAHONTAS WITH HER HIGH HAT AND RUFF.

the stream." She picked wild flowers as she went along, and hummed to herself the quaint old songs that she had caught from her father's books or from the glees she had heard at odd times. The maids of that day were fond of singing, and Mistress Judith's sweet voice trilled out along the banks of the Avon:

Come blow thy horn, hunter!
Come blow thy horn, hunter!
Come blow thy horn, jolly hunter!

echoing from hill to hill. And again:

For a morn in spring is the sweetest thing
Cometh in all the year.

Judith herself was like the springtime, radiant, fresh, and young, and it was no uncommon sight



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A LITTLE PRINCESS IN HER COURT DRESS.

AFTER A PORTRAIT BY McREELSE.

to see Shakespeare, with his grave face and quiet eyes, deep in converse with this favorite child of his, as they wandered along the winding course of the river.

Pretty Judith may not have had the learning of her predecessors who wore ruffs, but she was happier, no doubt, in her simple life, with her friend and gossip, modest Prue, reading together her father's plays, and building their own romances, girl-fashion, by their own firesides.

King James I. brought much learning to the court, and already love of adventure had lured some daring mariners to the New World. Sir Walter Raleigh, the Cabots, Captain John Smith, and many others had planted their first American colonies, and out on the virgin grass the practical dames of Holland, France, and England stretched their starched ruffs to bleach and dry, for, deary me! one must be fashionable, if there were only the home people and the wondering savages to see!

Little Pocahontas now rises before us, true child of the woods, this little Indian princess, with her lithe brown figure, her bare arms and feet, her dress of deerskin, her graceful neck wound about with the glass beads the white settlers had given her—a strange, innocent child of such a wily old chief as Powhatan, always ready to help her white friends in their need. We all know the story of how she saved Captain John Smith from a fearful death, and how ever afterward she was watchful to see that no harm came to her friend and his people. Many times she came through the woods to warn them of danger, and when they were nearly starving she brought

them food day after day; in truth, this little brown maid of the forest and stream loved the big blond captain whose life she saved so many times.

Old Powhatan proved so treacherous after Captain Smith sailed away to England that the colonists decided if they captured Pocahontas and held her as hostage, they might make terms with the crafty old warrior. The girl quite willingly went with them to Jamestown, where, little by little, she fell into English ways. She discarded the deerskin dress, the gaudy beads and dangling ornaments of her tribe, for the sober costume of an English maid, even to the white ruff which topped the high bodice; and when John Rolfe had made her his wife, behold little Pocahontas in brave attire, in ruff and high hat and all the fancies of the times, sailing away to that dim old England of which she had heard so much, and making her bow to the king and queen with all the haughtiness of a foreign princess—which, indeed, she was!

THE old, old times have gone. On that American soil a great nation has sprung up, and the girls with the ruffs have vanished with Queen Elizabeth and the rest. Girls of the same age to-day are blither, younger, and happier—no cares of the household, no distasteful duties, no stern parents to fret their daily life. Margery and Joan and Elizabeth of that time may have rustled proudly in their silks and stiff brocades; but Polly and Katharine of to-day, in simple muslins and white aprons, have no cause to envy their bygone sisters with the ruffs.



NATURE'S CURIOSITY SHOP

PART II

WILL THE WORLD'S FOOD SUPPLY EVER RUN SHORT?

It is quite plain and certain that, as people cannot live without enough food, there never will be more people than there is food for. But it is true, in a sense, that there is not enough food for all the babies that are born. The struggle for life is, in the first place, a struggle for food, and for a large number of people all over the world the struggle is so severe that many babies and children are killed by it, directly or indirectly.

But we know that the number of people in the world steadily increases, and doubtless always has increased since mankind came to be, except for short periods during some terrible war or pestilence. And steadily the amount of food has been increased by human effort. Men learned how to tame and care for sheep and oxen and goats, and so obtained flesh and milk. This pastoral stage—pastoral comes from the word pastor, which means a shepherd—yielded to the agricultural stage of growing crops, which supports far more human life than the pastoral stage alone can.

It is certain that some day there must be a limit, though, even with sixteen hundred millions of people on the earth, we are nowhere near it yet. When freed from the insects that carry disease, Africa alone will be capable of holding and feeding five hundred million people more than it does now.

HOW DO CLOTHES KEEP ICE COLD?

THAT is a good question; the best way to understand how clothes keep us warm is to learn how to keep ice cold. Well, now, if clothing is simply something that keeps back heat, as a blind keeps back light, what would happen if we put some clothing on the ice? If we choose nice warm clothing—which simply means that it keeps us warm—ought it not to keep the heat from outside from getting into the ice?

Now, that is exactly what happens. If we take the warmest kind of clothing that we can think of, which is flannel, and if we wrap the ice up in flannel, we keep the ice cool, and prevent it from melting. Now, do you not think that is rather funny? When we want to keep ourselves warm we put on warm clothing, as we call it; and when we want to keep ice cold we put warm clothing on it. Would you not almost have thought that the clothing which made us warm would make the ice warm too, and so make it melt? Well, so it would if the clothing were really warm, like a hot bottle. But then, you see, it is not really warm; there is no warmth in it at all.

HOW DID THE BLACK MEN GET BLACK?

Nobody knows the complete answer to a question like this, because the origin of the different races of mankind is lost in very ancient history, long before we have any definite records; but we know that we find black people living in the hottest parts of the earth, in many places where white men find it impossible to live. So that evidently the black races have developed some power of resisting the climate in these spots, and also the diseases peculiar to those parts of the world; a power of resistance which the white man has not.

As a result of this, it would come about that only those who were black could live and survive there, and in course of time there would be nobody except the black people in such places, a black race thus being produced by Nature selecting the blackest people as those best fitted to survive there. The blackness is probably the result of the continued exposure to the great heat of the sun in the tropical countries. Other people have thought that black was the original color of the human race, and that the white races have arisen from them. Whatever is the reason, the color of the skin evidently results from certain powers of human beings to adapt themselves to the climates in which they live.

WHAT DO FISHES FEED ON?

WE all know that the big fishes feed on the little fishes, but the little fishes must feed on something, and as it is very important that there shall be enough fishes for us to eat, it is very important to know what it is that the smallest fishes feed on.

We know that on the land plants are the producers and animals are the consumers; the same is true of the sea, which has its pastures, just as the land has. The sea contains vast quantities of humble plants together with humble kinds of animals, which feed on the plants, and these, between them, furnish the food for the smaller fishes.

The huge masses of tiny vegetables and animals floating in the sea have the special name given to them of plankton, and it is this that the smaller fishes and the youngest fishes feed on. It seems to be just at the time of year, in the spring, when the plankton is very abundant, and of a very suitable kind, that the small fry of most of our fishes are produced. Later in the year the plankton changes, and seems just to suit the young fishes when they have grown.

It seems to be clear now, also, that the action of light falling upon the sea has the same effect as when it falls upon the plants of the land. Much of the vegetable life that goes to make up this plankton has chlorophyll in it, or something which is a variety of chlorophyll—the coloring matter of green leaves—and by virtue of this it has the power of feeding on the gases dissolved in sea-water, just as land plants feed on air.

WHY ARE SALT-WATER FISHES NOT SALT WHEN CAUGHT?

THE part of the fish that we judge by is its muscles, which form its flesh, and which we eat. Though the fish swallows salt water, it only takes into its blood what it requires for the purpose of its life. If we look at it in this way, we shall understand how it is that the saltiness of a fish's muscles is not very different from that of a chicken's muscles. When we study the whole animal world, we find that the proportions of salt required in the water or in the blood that we find in the bodies of many different creatures are very much the same. The cells that make up muscles are very much the same in their way of living and their needs, whether we find them in a bird, a fish, an ox, or ourselves. Thus we should not expect to find the flesh of the fish saltier than that of another creature nor to find that it makes any particular difference whether the fish is a salt-water fish or a fresh-water fish. We must re-

member that the fish, like ourselves, has the power of choosing from the things which it swallows just those things which it needs for its life, and of taking them, and them only, into its blood.

HOW IS IT THAT FISHES DO NOT DROWN?

ALL animals and plants must get air in some way or other in order to live; or, to be more strictly accurate, they must have a supply of oxygen, which is one of the gases in the air. Should this supply of oxygen fail, death must come, no matter whether it be from drowning or from any other cause. When a man is drowned, what really happens is that, on account of his being so long under the water, his supply of life-giving oxygen has run short, and as he can only get it when he is in the air, he dies.

But this is not because there is no oxygen to be had in the water, for, as a matter of fact, there is quite a large amount of this life-giving gas dissolved in water, only human beings and animals breathing by lungs cannot make use of it. Their organs are only adapted for breathing air. The fishes, on the other hand, breathe by gills, not lungs, and the wonderful way in which gills are made enables them to extract the oxygen from the water. Being able to do this, they can live under water perfectly well. But if anything should happen to prevent the fish from getting oxygen from the water, or if anything should happen to the water to deprive it of its oxygen, then the fish would be drowned, as would any other animal.

HOW DO FISHES LIVE IN A FROZEN POND?

ORDINARY ice, we know, is lighter than water, and therefore it floats. So what we call a frozen pond is a pond of which the surface is frozen. Skaters are perfectly aware of this. They want to know how thick the ice is, for they know that there is liquid water underneath it. So when we speak about fishes living in a frozen pond, we mean fishes living in liquid water that has a layer of frozen water above it.

The really serious part of this for the fishes is not, as we might think, the coldness of the water they are in, but the question how that water is to be supplied with enough air for the fishes to live by. When a pond is not frozen, oxygen from the air above it is passing into the surface of the water as fast as it is being used up by the fishes and other living creatures in the water.

When a pond is frozen, this process is very

nearly stopped. There may be gaps in the ice here and there—air-holes, such as air-breathing creatures will make in the frozen North—but perhaps there may be none of these. A little oxygen may get through at the edge of the ice, but the best hope for the fishes is that there is a supply of new water coming into the pond below the ice from somewhere else, and bringing enough oxygen dissolved in it to keep the fishes alive. If the supply of oxygen is kept up in none of these ways, then, when there is no more of it left, the fishes will surely die, as must every living creature that is prevented from breathing, whether it be man, mammal, bird, reptile, fish, moss, or microbe.

HAVE FISHES ANY FEELING?

CERTAINLY they have. Everything that lives, from a microbe up to a man, has some kind of feeling. The power to feel and to respond to what is felt is a mark of all living matter everywhere, and its disappearance without return is the mark of death. But the amount and the quality and the clearness of feeling differ widely in various living things. So it would be equally wrong to say that a fish has no feeling, and to say that it feels as we do. It does feel, but it does not feel as we do.

Seeing is a kind of feeling, and perhaps a fish sees quite as well as a young baby does. A fish hears, too, and smells and tastes. Also, a fish certainly has the sense of touch. It can suffer a kind of unpleasant feeling, too, and must do so, for instance, when it has a hook in its mouth; but it would be a great mistake for us to fancy that it feels sharp pain as we should if we had a barbed hook in our mouths.

A fish has only a very simple kind of brain, and cannot feel so keenly as we do. So as to whether it is right to fish we should decide for ourselves, and act accordingly, but not condemn or ridicule people who differ from us in their opinion on the matter.

CAN A FISH HEAR?

ALTHOUGH fishes are like some other animals in having no visible signs of ears, yet they have ears which conduct sound to the brain. Their organ of hearing consists simply of an internal ear placed inside a gristly capsule. In some fishes—as, for instance, the dog-fish—there is a fold known as the *false gill*, which is no doubt the remains of a real gill, but is now used for transmitting sounds to the internal ear. In the wall of the capsule which contains the internal ear there is a thin spot, and it is through this thin part,

corresponding with what we call the drum of our own ear, that the sound is conducted. Thus, we see that in the case of some of the fishes there has been a change of function of an organ which was in the first place a gill, but has now become part of the hearing apparatus. In other words, it is a structure at one time used for breathing, but now used for hearing.

DO FISHES SLEEP UNDER WATER?

EVERY living creature has its time of rest. Even microbes rest, and plants, and certainly fishes. The answer to your question, then, is yes; only there is this to be remembered always. When we see a cat asleep, there is no doubt about it, and the difference between a sleeping and a waking cat is very much the same as the difference between a sleeping and a waking child. But the difference between a sleeping and a waking fish is not quite the same. We dare say the sleep of the fish is just like the sleep of the cat or the sleep of you and every one, but the waking of the fish is very different, and is very much nearer its sleep than your waking is to your sleep. What we mean is that the fish has such a poor, feeble glimmer of a mind—fishes are really very stupid—that even when widest awake it is still half asleep, compared with what we are when we are awake.

DO FISHES SHUT THEIR EYES

No; fishes do not shut their eyes. It is quite possible for us to sleep without the eyes being shut if it were not for the trouble of keeping our eyelids up. Now, an animal cannot shut its eyes unless it has something to shut them with, and the only things that can shut eyes are eyelids; and all the ordinary common fishes do not have any eyelids.

They are not the only animals like this. If you will look at the snakes in a zoo for a minute or so, you will notice that they always seem to have their eyes wide open with a fixed stare, although they may appear to be, and perhaps are, fast asleep. This is because the snakes, like the fishes, have no proper eyelids which they can close. But there can be no doubt that when fishes rest, for instance, at the bottom of a pond or river, they sleep in the usual way, only they sleep with their eyes wide open, simply because they cannot shut them.

WHEN BEES TAKE HONEY DO FLOWERS GET MORE?

It is a mistake to suppose that bees get ready-made honey from flowers. No flowers contain

honey as we know it; honey is a thing specially made by the honey-bee from materials derived from the flower. The sugary material produced by the flower is not honey, and does not exist to serve the bee. It is made by the flower for its own purposes, but it serves the flower indirectly, because the visit of the bee is of value in helping to fertilize it.

The flower does get more of this material, although it can by no means make a fresh supply at once, because the production of the sugary substance to which the bee helps itself is a long and difficult chemical process, depending upon sunlight, the drawing up of water from the soil, and the slow building up inside the plant of sugar and other very complicated chemical materials from the very simplest things.

WHY DO BEES STING?

THE use of the bee's sting is exactly the same, in its own way, as the use of the nettle's stinging hairs. The sting is really a fine, sharp, barbed tube, through which a drop of poisonous stuff can be sent when the bee stings. The bees that sting are the worker-bees—those that do the work of the hive. The case of wasps is the same. A bee or wasp can sting only once, for the barb, which is such a nuisance to us when we are stung, prevents the sting from being withdrawn. It is torn away from the bee's body, and the bee is so injured that it soon dies. Thus a bee stings only when its position is desperate.

The case of the bee's sting is interesting, for it shows how completely each bee is made for the good of the whole hive. No other creatures in the world show this so well. It is actually armed with a weapon which, to be effective, has to be made so that its use kills its owner, and it is not a weapon of offense even, but of defense only, and only for extreme cases.

The lesson is that when we are stung *we* usually begin the quarrel. We make ourselves offensive to the bee. If we do not, it will never dream of stinging us. Many naturalists make friends with bees and wasps, and let them crawl on their hands and faces, and never get stung. But, if you get out your handkerchief and attack the bee, it is bound to do its duty, even at the cost of its life, and you have to pay a price too.

WHY DOES A BEE DIE WHEN ITS STING COMES OUT?

WHAT we call the sting of a bee is not really meant to be used as a sting. It really exists to

help the bee lay its eggs, and when the bee uses the sting, as we call it, it is roughly torn away from the bee's body, causing damage which is soon fatal. This is a very curious case where part of an animal's body has had its real purpose changed; but the change has required a heavy cost, for the sting cannot be used except at the cost of the bee's life.

This means that to use its sting is an act of suicide on the part of the bee, and if a bee lived for itself, this would indeed be a foolish means of protection. But every bee lives for the hive, and the real use of the sting is not to attack us, for instance, when we hit at a bee with a handkerchief, but to protect the bee-hive from its enemies. The bee's sting is not a weapon of offense, but of defense—not self-defense, but hive-defense. It is used only under provocation, and only for the sake of others and the future of the bee race. The bees that sting do not themselves lay eggs, and so it is that they are able to turn this part of their body to quite a new and utterly unselfish purpose.

WHAT MAKES A BEE HUM?

THE humming of the bee and of so many other insects is not like the murmur of the sea-shell, which picks up sound like a telephone, but is made by the bee itself. You have never heard a bee hum when it was crawling—nor any other insect. This tells us what we might have guessed, that the bee's humming is made by the movement of its wings when it flies. The noise is not made by a voice-box, as when you sing, for the bee has no voice-box. But its wings move very quickly—a bird would hum when flying if its wings moved quickly enough—and as they move to and fro, or vibrate, they set the air moving too, and you know that waves in the air make sound when we hear them.

If the waves are too slow, as when you wave a stick in the air, or when a bird flaps its wings, we hear nothing. If they are too fast, as they are in the case of some insects, perhaps, and in other cases, like the scream of the bat, we cannot hear them; or, to take the bat, some people can hear them, but many, and especially old people, cannot. Thus there are many sounds we cannot hear, as there are many colors we cannot see. But the vibrations in the air made by the bee's wings are of a rate that is within the range of our hearing—if the bee is near enough—and so we hear a humming. We are sure you will guess that that word, like "murmur," is made to imitate the sound of which it is the name.

WHY DOES THE POISON INSIDE THE WASP'S BODY NOT HURT IT?

THIS question would be interesting enough if it applied only to wasps, but it is really far more interesting, as we can ask just the same question about a vast number of animals and plants that contain substances poisonous to creatures of other kinds, but not to themselves. For instance, why should a poisonous serpent, biting itself or another serpent of the same kind, do no harm, except just the harm caused by its teeth?

We are gradually coming to realize that the answer is to be found somewhere in the chemistry of life. The fact that different creatures differ from one another must mean, among other things, that each kind of creature has a chemistry peculiar to itself. That, of course, is the real explanation of the fact that one man's meat is another man's poison, that the wasp's poison is not poison to the wasp, nor the snake's poison to the snake.

Each kind of creature, then, has its own special chemistry. For the purposes of its own life it produces certain substances, useful as means of offense or defense. But it is in the very nature of the case that no kind of living thing could produce and retain substances poisonous to itself and continue to exist.

DO FLIES LAY EGGS?

As nearly all the flies die this year, leaving few to struggle through the winter, it seems strange, of course, that next year we shall have as many flies as ever. The reason is that the female fly lays an egg that changes into a chrysalis, and is kept in that form during the winter, until the warm weather of spring brings out the young fly. The eggs turn at first into maggots, and from maggots into pupæ, which are a sort of chrysalis. In the chrysalis the body of the new fly forms. Millions and millions of flies lay eggs in the autumn. If all these eggs hatched at once, nearly all the flies would die during the winter. Now, the first touch of cold causes the living insect in the chrysalis to stop growing, to become dormant like the bear asleep in winter. A fruit-bud on a tree, when a frost comes, goes to sleep and does not open until warm weather has set it growing again. So it is with the chrysalis of the fly. The maggots from the flies' eggs can bore and tunnel like worms, and make their way to safety, so that they can, in their chrysalis form, lie safe and snug all the winter.

CAN FLIES HEAR?

THE more we study the senses of different ani-

mals, the more do we learn that the sense of hearing ranks high in the scale, and comes late in the history of the progress of life; and thus we find that various creatures, whose powers of touch and of smell and of vision are marvelous, seem to be almost, or entirely, deaf. There are a few insects which can hear, but the greater number, including flies, cannot hear at all. Every imaginable kind of sound has been tried, and insects, with the exception of very few, take no notice whatever. Lord Avebury thought that perhaps insects might respond to sounds of so high a pitch that our ears cannot hear them, but he could not get them to take any notice.

The highest string of a violin has been scraped an inch away from bees engaged in pillaging flowers, and they have taken no notice whatever. The senses of insects, including flies, are so wonderful, and in some respects so superior to our own, that it is immensely interesting to find that nearly all insects, including not only the flies but the highest insects, such as the bees, the ants, and the wasps, are perfectly deaf.

CAN A FLY SEE ALL WAYS AT ONCE?

A FLY cannot see quite in all directions at once, because, whatever the shape of its eyes, one part of them, at any rate, must lie against the fly's head, and in that direction, at least, the fly cannot see. But it is true that the eyes of flies, and of many other insects, can see in far more directions at once than ours can. This is especially the case where the eyes are not flat, but very much rounded and bulging.

We must not suppose that this means clear vision at one and the same time in all these directions; but it does mean that, while looking in one direction, so to speak, the insect can get a hint of movements much farther round the corner than we can. The proper way of saying this is that their field of vision is very large, even though it does not quite amount to seeing "all ways at once."

In order that the eye shall be able to receive light coming from so many different directions, it is made somewhat like a precious stone that has been cut into many little faces, or facets. The number of these tiny, flat facets on the eyes of insects is extraordinary. A male ant, for instance, may have twelve hundred facets on each eye, and the number on the eye of the dragon-fly has been reckoned as high as seventeen thousand.

HOW DO FLIES WALK ON THE CEILING?

WE ask, Why can flies walk upside down? which sounds more wonderful still. The reason, no

doubt, is that the fly's feet, besides being just the least little bit sticky, are made like suckers, and hold on to whatever the fly walks upon, just as a boy's sucker will hold on to a stone, so that he can lift the stone by means of it. Then, of course, we have to remember that the fly's body itself is very lightly made, just as a bird's body is, because both are meant to fly; and this makes it easier for a very little force to prevent the fly from falling even when it is upside down.

WHERE DO FLIES GO IN THE WINTER?

Most flies live their lives in spring and summer, then die. Some of them are fortunate enough to find a place where they can hide and obtain warmth to keep them alive. They hide in quiet places about the house, in out-buildings, in the fields and stables, where we should never dream of looking for them. They do not feed. They simply lie dormant, sleeping as a squirrel in his nest, or a bear in his den, or a tortoise in his shell, sleeps the cold days away. But an unexpected warm day in winter comes. The fly feels the extra warmth. It wakes him, makes him hungry, and sends him forth to seek food. The warm day passes, and he may get back to safe hiding; but most likely he will not. Probably the cold will return and kill him. Very few flies manage to get through the winter. If they are not worn out and ready to die at the end of the summer, many of them are killed by a fungus which, floating in the air, settles on their bodies, drives roots into their insides, and destroys them. Those we see dead on the window-pane, swollen, with a little halo on the glass about them, have been killed in this way.

IS A FLY, IN COMPARISON WITH A MAN, THE STRONGER?

EVERY one will know what this question means, and yet it might be better put. So far as the words go, the question might mean to some, If you compare a fly and a man, which is the stronger? But you must know that what the question means is this: "Is a fly really stronger than a man in proportion to its size?" The answer is certainly yes. The last thing in the world that distinguishes man is bodily strength of the kind which is shown in lifting weights, and so forth. It is by *skill*, made not by the muscles, but by the brain, that man lives on the earth—skill, not strength. If we weigh the proportion of the bodies of different animals that is made of muscle, and if also we weigh the proportion that is made of brain, then we learn how muscle has been getting less and less important,

while brain, with all that brain means, has been getting more important. Not only a fly, but animals in general are the superiors of man so far as muscular strength is concerned; but then the question of muscular strength is an inferior one, and man is master because of what really matters, which is mind. The race is not to the swift, nor the battle to the strong, but to the wise, who will use their brains.

WHAT IS THE USE OF A MOTH?

HAIR and wool are rubbed off the thousands and thousands of hairy and woolly animals in the world, and if the hair and wool were never destroyed they would, in the course of many years, become a great nuisance. The moths eat them and so prevent us from suffering from such a nuisance. But moths eat our clothes, it may be said. Moths never eat the clothes which we have on, or the clothes which we wear regularly. If you have too many clothes to wear, you should give them to poor persons who have not enough. So that moths teach us not to be greedy, not to hoard up things which others would be thankful to have!

WHY DOES A MOTH FLY ROUND AND ROUND A CANDLE?

No one can say what it is in the brain—or beginnings of a brain—of the moth that decides it to like the light; and it is quite clear to every one that this liking does the moth no good—at any rate, in the case of such a light as the candle. It may possibly be that it benefits the moth, and other creatures that behave like it, to fly toward light from darkness; and perhaps we should find this to be so if we knew enough of the lives of these creatures. But much study has lately shown that animals and plants can be divided into those which go naturally from darkness to light, and those which go naturally from light to darkness. Learned names have been applied to these habits—names which mean that the creature turns sunward or away from the sun. Different plants and different parts of the same plant behave in similar ways; and if we notice the behavior of a baby toward a bright light we shall see that it is really like the moth. We find also that different creatures tend to move toward or away from other things besides light—such as heat, gravitation, electricity, and all sorts of chemicals and smells. Some grown-up people are like the moth—they move to the sunny side of the street; and others are like insects that usually live in darkness and fly toward it—they move to the shady side of the street.

WHY DOES THE SEA NOT FREEZE?

SEA-WATER, like any other kind of water, can freeze, and it does freeze if the conditions are right; but there are some good reasons why the sea does not freeze nearly so easily as a pond or lake, or even a river. It is not the salt in sea-water that makes the difference so much as the depth and constant motion of sea-water. Until the whole depth of a quantity of water has been cooled down it cannot begin to freeze, for, until it has all cooled, the warmer water, being lighter, must always come to the top. Therefore, when water is very deep, it is very difficult to freeze, and thus the great depth of the sea is one of the chief reasons against its freezing.

But the sea is also in constant movement under the influence of tides and winds and currents. The motion of water interferes very much with its freezing, though it does not interfere nearly so much as the depth.

But in the coldest parts of the earth's surface the sea does freeze, as we find in the records of those explorers who have attempted to reach the north or the south pole. The same seems to be the case on our near and wonderful neighbor, the planet Mars, for we can see through our telescopes the ice or snow-caps at each of its poles, like the ice at our own.

WHY IS THE SEA SALT?

It is the rivers that make the sea salt. The sea was first made by the water that was in the air falling into all the deep holes on the earth. That was the first rain that ever fell, and it was quite fresh, like all rain—that is to say, there was no salt in the water. Thus the sea at first was made of fresh water. But there are all sorts of salt in the earth, and as the rivers run into the sea they melt the salt out of the ground they run over and carry it into the sea, although when the sun sucks up the water again and makes the rain it does not suck up the salt with it.

Now, it is the water sucked up by the sun that makes the rivers, and so the rivers start with fresh water; but by the time they have reached the sea they have melted quite a lot of salt, which they add to the salt already in the sea. So from day to day, and from age to age, the sea gets saltier and saltier; and wise men have even guessed the age of the sea and the length of time that the rivers have been running into the sea by noticing how much salt the rivers carry into it every day. Then it is not a hard sum to find out how long it must have taken for the sea to become as salt as it is now.

IF RIVERS MAKE THE SEA SALT, WHY ARE RIVERS FRESH?

THE river is not really fresh, but a little salt, and it is largely because the river is a little salt that the sea is very salt. It is true that river-water may taste fresh to our mouths, but that is because we are not accustomed to the taste of water that really contains no salt. If we taste, one after the other, two tumblers, one containing river-water and one containing sea-water, we should certainly know which was which; but if we took two tumblers, one containing river-water and the other containing water which contains no salt, and none of the dissolved gases which help to make salts, then you would find it just as easy to tell which was which as in the first case, because you would taste the salt in the river-water. Thus we see how much our knowledge of things depends upon the training of our own senses to note the fine differences in what Nature provides in her wise chemistry.

WHY DOES NOT SEA-WATER MAKE FISHES THIRSTY?

WE might almost answer this question by another: How do we know that fishes are not thirsty? It is not at all easy to find out how much water fishes drink; but, like every other living thing, they require water, and perhaps they take a good deal. Certainly it is always at hand. We do not find that the muscles, for instance, of a fish contain higher proportions of salts than do the muscles of other animals; nor can we show any particular difference between the amount of salts in the body of a fresh-water fish as compared with the amount in the body of a salt-water fish.

We know that many fishes travel about in the course of their lives from fresh to salt water, and from salt to fresh, but no one is yet in a position to tell exactly what the fish does in these cases. It certainly is very clever to be able to adapt itself so well to such very different kinds of water. This can only mean that the organs of its body which are concerned with keeping the composition of the blood right are able, when occasion requires, to filter an excess of salts out of it very quickly. The same is true of our own bodies, fortunately for us, as we often take food and drink containing an excess of various things which certainly must not stay long in the blood. On the other hand, we are not adapted to keep the composition of the blood right if we drink nothing but sea-water, as fishes can without harm.

WHY IS IT EASIER TO SWIM IN SALT WATER THAN IN FRESH?

SWIMMING has two parts, really—one is to keep up in the water, and the other is to move along in it. The question really is: Why is it easier to keep up, or to float, in salt water than in fresh? The answer depends wholly on the heaviness of our bodies as compared with the heaviness of the water. Our bodies are more than three-fourths water, but most of the rest is heavier than water. The fat of our bodies is lighter than water, and so helps us to float.

Now, fresh water is less heavy than salt water, and so our bodies, though only a little heavier than it, tend to sink in it. Ordinary sea-water is heavier than fresh water, because it contains a lot of salts melted in it, just as the water of our own bodies does; so we find it easier to float and swim in sea-water. But in some parts of the world there is water that is much saltier than even sea-water; this is the case, for instance, in the Dead Sea, and in the Great Salt Lake in Utah. There is so much salt in the water of the Dead Sea that it is actually heavier, on the whole, than our bodies are, so you cannot sink in the Dead Sea! On the other hand, there are some liquids much lighter than water, and if a man were to fall into a lake of one of them he could not swim at all, however good a swimmer he was; his body would sink like a stone in such a light liquid.

WHAT MAKES A WHIRLPOOL?

We make a little whirlpool when we stir our tea, and a whirlwind moving above water will set it whirling for a time. But in many parts of the world there are great whirlpools which remain from day to day or from century to century. The cause of them is the meeting of two currents of water, especially rapid and strong currents. When we take a top or a ball and hold it between our hands and spin it by pushing one hand from us and pulling the other hand toward us, we really see exactly how two opposing currents may treat the water where they meet.

There is a great whirlpool below the falls of Niagara; another, about which wonderful stories have been told, is the famous Maelstrom off the coast of Norway; but the most famous of all is the whirlpool called Charybdis, in the Strait of Messina, which separates Sicily from the mainland of Italy. We know that this whirlpool existed thousands of years ago, but the region is terribly liable to earthquakes, as every one now knows, and it is said that the position of Charybdis has been altered in consequence.

Not far from where Charybdis used to be was a great rock very dangerous to sailors; its name was Scylla. It was a great difficulty for small ships to pass between the whirlpool and the rock without being engulfed in the one or wrecked upon the other, and to this day, when a man has to steer his course of life very carefully between two dangers, we say that he is between Scylla and Charybdis.

WHY ARE ROUGH WAVES STILLED WHEN OIL IS THROWN ON THEM?

WE must not think that we can abolish waves altogether by throwing oil upon them. The waves, driven by the wind, will go on as they did before, but it is just the surface of the water, including the waves, that is affected by the oil. The oil is lighter than the water, and floats on its surface. Though it is lighter, yet it is a very different kind of liquid, and the molecules making it up are much more closely attached to each other than the molecules of water are. We have a special word for this difference in liquids. We say that some are more mobile than others, which simply means that they are more movable; and we say that some are more viscous than others, which simply means that they are more sticky. Water is very mobile, though not quite so mobile as some liquids, such as "sulphuric ether," which is used for sending people to sleep; and oil, on the other hand, is very viscous, and will not dissolve in water. A mobile liquid, when it is shaken, readily breaks into drops, and so forms spray; but you can scarcely make a spray of oil, whatever you do to it. So, by pouring a layer of the very viscous liquid oil on the mobile liquid water, we stop the spray, though we do not stop the waves, and we prevent the waves breaking, as they would otherwise do, against the sides of the ship. This may be well worth while, as it may mean that only a very little water, or none at all, is brought aboard, where, before, every wave was breaking and threatening to waterlog the ship.

Although, then, it seems very curious at first sight that one liquid should be able to float on the surface of another, if we think carefully about it we see at once that whether a thing floats on the surface of water or not depends upon one or two things. First, it depends upon whether it is soluble—that is, will dissolve—in water or not. For instance, if we put a piece of salt in water it disappears, because the salt is soluble in the water. If, however, we put a piece of light wood on water it floats there, because it is not soluble, and therefore remains intact, and also because the weight of the piece of wood is less than an

equal portion of water. It is much the same with oil. Oil and fat are quite insoluble in water, and as the oil is considerably lighter than the same bulk of water, it floats on the surface.

WHY DOES AN ICEBERG FLOAT?

IF we were to judge by almost every other case we know, we should say that an iceberg must certainly sink. The rule is that when anything is cooled it gets denser—that is to say, heavier in proportion to its size. In other words, it contracts. If this were true of water, ice would have to sink, and our earth would not be the earth we know.

Water certainly contracts as we cool it down to four degrees centigrade above the freezing-point. But from this point downward water expands instead of contracting, so that ice is slightly lighter than the water around it. The difference is not very great—it is just enough to allow an iceberg to float with about seven-eighths of itself below the surface of the water and one-eighth above it.

In the Antarctic Ocean one may see icebergs that are actually miles across, and they may rise two or three hundred feet above the surface of the water. But the laws that govern floating must always be obeyed; and if we remember that there must be seven times as much ice below the surface as shows above it, we shall get an idea of the enormous size that masses of ice sometimes attain. The part below the surface is, of course, surrounded by liquid water, which is warmer than the ice. Consequently, by the laws of heat, there must be a flow of heat from the water to the ice, which therefore melts. The result often is that, after a time, owing to the destruction of the foundations, so to speak, the iceberg capsizes, and a new part of itself shows above the surface.

It has been lately proved that when ice is made very cold indeed, a point is reached when it begins to behave as other things do, and shrinks as it cools. But, fortunately, this point is far below any temperature that occurs naturally on our earth.

WHAT MAKES A WATERSPOUT?

JUST as the waves of the sea are due to movements of the air, so the very astonishing disturbance of the sea called a waterspout is also due to an unusual disturbance of the air. Sometimes parts of the air get started in a twisting motion, rushing through the air and at the same time turning round and round very quickly, somewhat

as the earth rushes through space and turns round all the time. When this happens the sea may be very violently disturbed; and sometimes in the middle of this twisting portion of air there is very little air indeed—it is almost like a hollow twisting column of air. Then the water just beneath may be suddenly sucked up so as to fill the almost empty space inside this twisting column of air, and that makes a waterspout.

WHY DOES THE STREAM RUN MOST SWIFTLY IN THE MIDDLE?

THE water at the side of the stream is constantly being held back by rubbing against the banks, just as the bottom of a wave is held back when it reaches the shallow water near the shore. And so, compared with the water near the sides, the water in the middle of the stream runs more swiftly. It is held back a little by rubbing, or friction, between it and the slower-moving water at the sides; but the friction between water and water is very much less than the friction between water and anything that is solid, such as the banks of a stream.

When we watch the blood running in a blood-vessel, we see exactly the same thing. In the middle of the stream we see the tiny red and white cells tumbling fast over each other as they scurry along. But near the walls of the blood-vessel they move much more slowly, for they are held back by the friction of the wall, even though it is beautifully smooth. And just the same thing happens with smoke going up a chimney, and in many other cases. We should always try to think, when studying such a question as this, of other cases where the same principle of friction is really at work.

WHAT IS A DEWDROP?

THOSE tiny beads of water look very simple, but it took wise men hundreds of years to find out what they are. Then they found that a dewdrop is part of something very important indeed. There is in the air a great deal of moisture, which cools the rays of the sun so that we are not burned on a hot summer's day. At night, when the earth passes out of the sunlight, the earth lets out the heat that it has stored up by day, and the moisture causes the heat to escape slowly. If it did not the earth would suddenly become so cold that we should be frozen to death in a single summer's night.

Well, in the evening, when the earth begins to give off its rays of heat, the moisture in the air drinks in the rays, so that the moisture becomes

warmer than the earth and the grass and the flowers, from which the heat-rays have come. The grass and the flowers become very cold after losing their heat, and as they grow cold they chill the moisture near them. The moisture, when it becomes cold, turns to real water and falls toward the ground like rain, and the blades of grass, or the leaves of trees, or the spider's web, catch the drops as they fall, and the water, trying to keep itself together as much as it can, gathers into tiny beads. These are the dewdrops.

WHERE DOES THE SPRING-WATER COME FROM?

SPRING-WATER comes from the sky. If we live in the country, we soon find that the springs are dependent upon the rain, and when there is little rain, or none at all, the springs shrink, or may even dry up completely. This is true, even though the spring-water is seen coming from the earth. It is rain-water that has soaked into the earth, and then found its way to the surface again at the spring. And the spring-water runs at last into a lake or a river, and so to the sea, from which the sun sucks it up again, to send it down as rain. This goes on ceaselessly; and so the water of the spring has been round and round, in spring, sea, sky, and earth, countless thousands of times before we were born, and will be doing so hundreds of years after we are dead.

Spring-water is very good to drink, for it is very pure, it contains a lot of air dissolved in it which gives it a pleasant taste and sparkle, and it has dissolved into itself from the earth through which it has passed a number of different salts that are very good for us.

WHY HAS WATER NO TASTE?

It is perfectly true that pure water has no taste, but probably not one in ten thousand of those who read this question have ever tasted water that had no taste. None of us have ever tasted pure water, unless we have been to the chemist's and have tasted water that has been distilled. The ordinary water we drink has quantities of air dissolved in it, and these give it a taste. It also has a certain amount of salts dissolved in it. If we boil water, we drive off the gases in it, and then it does become tasteless and flat. That is the reason why one of the many ways in which to spoil a cup of tea is to let the water go on boiling before we make the tea. Why pure water should have no taste is very plain. Our bodies mainly consist of water. The nerves of taste, and their endings in the tongue, mostly consist of

water themselves, and they live in water. Therefore we should not expect water to be one of the things that excites them. If it were, we should be tasting it all the time. There would be no use or meaning in this, and all our senses exist for use. Their business is to tell us of new things happening, not of things always there. So water, therefore, has no taste, and air no smell.

WHY DOES WATER RIPPLE WHEN WE THROW A STONE INTO IT?

THIS is an easy question to answer if we remember one or two great facts that are true everywhere and always. There may be great waves in the sea, though there is no wind, because those waves have traveled from where they were made. That is exactly what happens when you throw a stone into a stream or a pond. The wave-motion, as we call it, starts where the stone falls.

Now, it is one of the great laws of Nature that when anything is at rest it stays at rest until something moves it; and when anything is started moving it will go on moving until something stops it.

If nothing stopped it, it would go on moving for ever and ever. This applies to the stone that you throw, and it applies to the wave the stone makes when it strikes the water. When a stone strikes water, or when a sound is made in the air at any point, or when a light is made, a wave motion in each case is started, which travels out from the point where it started in all directions, and will go on traveling for ever unless something stops it.

Of course, one of the things which stops it in the case of a water-wave is friction, which simply means rubbing, as the parts of the water push against each other. Then it is quite natural that, as the wave gets bigger and wider, it spreads out its power over more space, and so the waves are not so big when they reach the bank as they were when they were started.

WHY DOES WATER GURGLE WHEN IT COMES OUT OF A BOTTLE?

WE know that the air has a pressure, and so, if there is an empty space anywhere, the air will press into it. Now, when we pour water out of a bottle which is full, there must be an empty space left behind in the bottle when the liquid comes out, and from moment to moment, as that empty space tends to be formed in the bottle, the air outside is bound to rush in to take its place. If the bottle has a wide mouth, like a tumbler,

then, as we pour the liquid out, air can flow in evenly, and there is no gurgling.

But if we take a full ginger-beer bottle, and hold it upside down, then there is a series of fights going on between the liquid, which is trying to get out under the pull of gravitation, and the air, which is trying to push its way past the liquid to fill up the space in the bottle. Sometimes the air pushes back the ginger-beer, and sometimes the ginger-beer pushes back the air. This means that the air is thrown into little disturbances, which we hear as gurgles. We say that water gurgles, but really, of course, it is the air that is disturbed by this contest between it and the water, and we call these disturbances "gurgles."

WHY DOES NOT WATER FALL OUT OF A REVOLVING PAIL?

WE must remember that every substance, whether it be a solid or liquid, tends to remain in the same position unless some force is applied to it to move it. The force of gravity keeps the water in the bucket when the bucket is at rest, and attracts both the bucket and the water to the earth. When we swing the bucket quickly over our heads, gravity would cause the water to fall out if we held the bucket still, but by keeping it moving we bring other forces into action which act in other directions, and tend to make the water press against the sides of the bucket.

If the water could get out it would not fall straight down to the earth, but would go on some distance in the direction in which the bucket was moving at the moment, and would gradually come to the earth. So that the water stays in the bucket as the result of the several different forces acting upon it while it is being swung quickly round and round.

WHEN WATER IS BOILING, WHY CAN IT NOT BE MADE HOTTER?

WHEN water is boiling it can be made hotter, but not as liquid water. Water, like other things, has a certain temperature above which it cannot be a liquid, but must be a gas, and below which it cannot be a gas, but must be a liquid or a solid. That point we call the boiling point. We cannot make water hotter than boiling point, because when we do it ceases to be what we usually call water, and turns into gaseous water, or water-vapor, but it is quite possible to make water-vapor hotter than the temperature of boiling water. If we go on boiling water, we are certainly putting heat into it; and we must not fancy that because the liquid

water gets no hotter, the heat is being lost, or wasted, or turned into nothing. Nothing is ever lost, or turned into nothing. What the heat does is to put itself into the liquid water, so that that liquid water takes the form of a gas, and the heat still remains, though rather changed, in the energy of movement of the parts of the gas. We can easily prove that the heat is doing something, though it is not making the water hotter, when we find that if we go on boiling we boil all the water away; that is to say, we turn the whole of it into water-vapor.

WHY DOES STEAM ALWAYS COME WHEN WATER IS HOT?

WATER evaporates, as we say, at all temperatures. Whether hot or cold, it slowly leaks away into the air in the form of a gas. As this remains a gas, we do not see anything. But when water is made hot, it very quickly passes into the air as a gas. It passes so quickly that the air cannot hold it all, and it is so much hotter than the air, that it is cooled in the air and turned into drops of liquid water again. It is this little cloud of drops of wet water in the air that we call steam. Water-vapor ought not to be called steam. The gas, or vapor, only becomes steam when it ceases to be a gas, and becomes liquid water again.

Thus the name steam-engine is really a very bad one. Steam is what we see escaping from it, but steam—that is to say, a cloud of drops of liquid water—would never drive the engine, as every engineer knows. The kind of thing that does the work he wants is what he calls "dry steam." It is not steam at all, but water-vapor. When he first lights his fire, he gets what he calls wet steam—the engine is cold, and it turns the water-vapor, which comes from the water as it gets hot, quickly back into steam, or wet water, again; and it is a poor business trying to run an engine on "wet steam." But all steam is really wet, and you see that we use the word wrongly. It is not steam but water-vapor that drives a steam-engine; and the water-vapor turns into steam only when its work is done and when it can do no more.

WHY IS THE AIR FRESHER AFTER IT HAS BEEN RAINING?

THERE are several answers to this question. For one thing, the rain washes the air, as water will wash anything else. If the air has contained a number of smoke-particles, as it does in large cities, the rain has reduced their numbers by carrying them down with it as it fell through the

air. Thus the rain helps to rid the air of the sulphurous and other gases which are given off by these smoke-particles. Then again, it now seems that the falling of rain often, or always, depends in part on electrical charges in the air, and these charges may help to produce small quantities of the gas called ozone, a variety of oxygen, which has a fresh smell of its own. Then, rain cleans the roads, and washes away all sorts of things which give off smells. We do not realize the extent to which rain is a cleanser in cities; and we must remember that our noses are usually only a few feet above the surface of the street, so that they are fully exposed to whatever arises from it. A few hundred feet up, the air would smell very differently.

IS SMOKE BLOWING DOWN THE CHIMNEY A SIGN OF RAIN?

It may be, or it may not be. If we think about this question for ourselves, we shall see that no one could answer simply Yes or No to it, for so many different things come into it. The traveling of smoke up a chimney and of wind down it are complicated matters.

We may be sure that when the wind blows down the chimney the air is not still, and wind very often brings rain, for wind is moving air, and this air may be laden with moisture, which is apt to fall as rain.

But though wind and rain often go together, so that rain is more likely to fall when the smoke is blown down the chimney, yet there are winds which are usually dry, and bring no rain with them. Different chimneys smoke with different winds, and some smoke with all winds, and some with none; so, plainly, it is impossible to answer this question, except in a general way.

WHY ARE SOME THINGS POISONOUS?

WE could only answer this question completely and fully if we knew all there is to know about life. Plainly, unless we understand life, we cannot understand entirely why certain things cause death. But we know enough about certain great facts of life to explain why a great many poisons are poisonous. And it is deeply interesting to learn that many things which poison us also poison every kind of animal and every kind of plant—a man, a worm, an oak, a microbe. The living stuff which makes the living part of all these and all other living creatures is called *protoplasm*, and the poisons which destroy all forms of life are called "protoplasmic" poisons. Their deadly dose varies, and some of them are valuable as

medicines in small doses; but there is no question as to their real nature, and it can be explained. The best-known protoplasmic poisons are prussic acid, arsenic, phosphorus, alcohol, and chloroform.

The first and most urgent need of all life is to breathe, and so we might expect these poisons to act by interfering with breathing—not so much with merely getting air into the lungs, but with the real breathing, or burning, which goes on in a muscle, a leaf, a microbe, or any other living creature. And we find that, in their various ways and degrees, the protoplasmic poisons interfere with the *oxidation*, or the burning or breathing, of the living cells.

Prussic acid, alcohol, and chloroform stop the working of the breathing-center in the brain, and they also prevent oxygen getting loose from the red cells in the blood. They fasten it to these cells, so to speak, so that the cells that really want it are suffocated and die.

WHEN WE FEEL COLD, IS OUR BLOOD COLD?

OUR feelings of cold or heat come, as a rule, from the very surface of our bodies. What we judge by is what happens to the skin. If the skin is losing heat quickly, we say we feel cold, and if it is losing heat very slowly, or actually gaining heat, we say we feel hot. The blood is the most important thing which decides how the skin feels, as a rule; but, of course, in special cases the skin is more affected from outside than from inside, as when we are in a cold draft or exposed to a fire.

When we feel cold, our blood is not cold. It is as warm as usual. Only very little of it, however, is passing through the skin, and that is why the skin feels cold. Perhaps we are in cold surroundings, and the body is keeping most of the blood to warm the great organs like the brain and the heart, and the skin, which does not matter at all compared with them, has to go short.

In certain illnesses the case is very striking. In malaria, for instance, there is usually a shivering stage, when the person feels very cold. His skin also is pale, and there is very little blood in it, and that is why he feels cold. But if we take the pains to find out in some way the actual temperature of his blood, we shall find that it is much hotter than it ought to be.

The person is, indeed, in the first stage of a fever. In the second stage this hot blood will flood the blood-vessels of the skin, and the quantity and the hotness of it will make the person feel as hot as he previously felt cold.

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